Iron and Steel ENGINEER

ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

TECHNOLOGY DEPT.
JUNE, 1957
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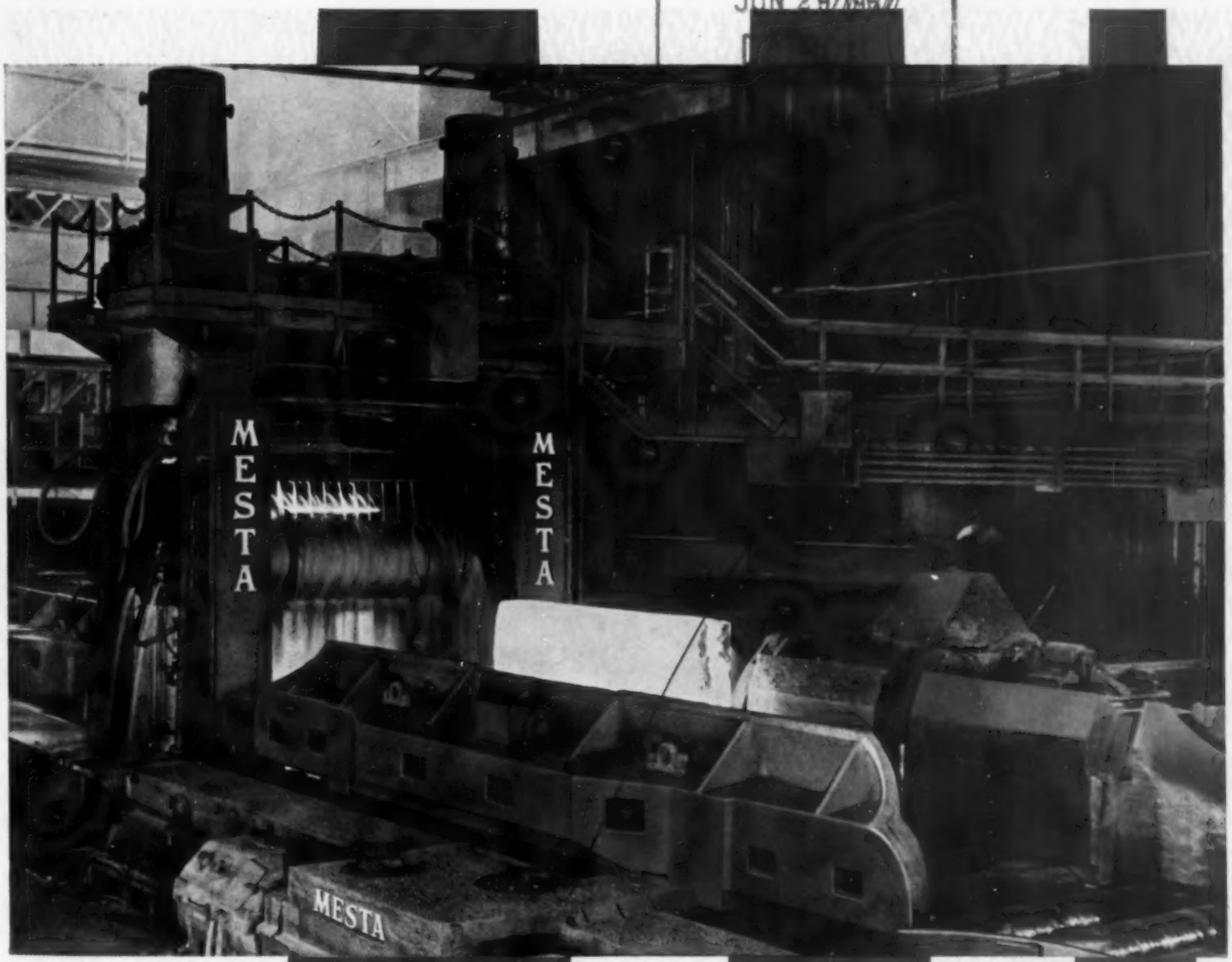


MESTA 46" TWO-HIGH REVERSING SLABBING-BLOOMING MILL WITH MANIPULATORS AND TABLES

SLABBING-BLOOMING Mills

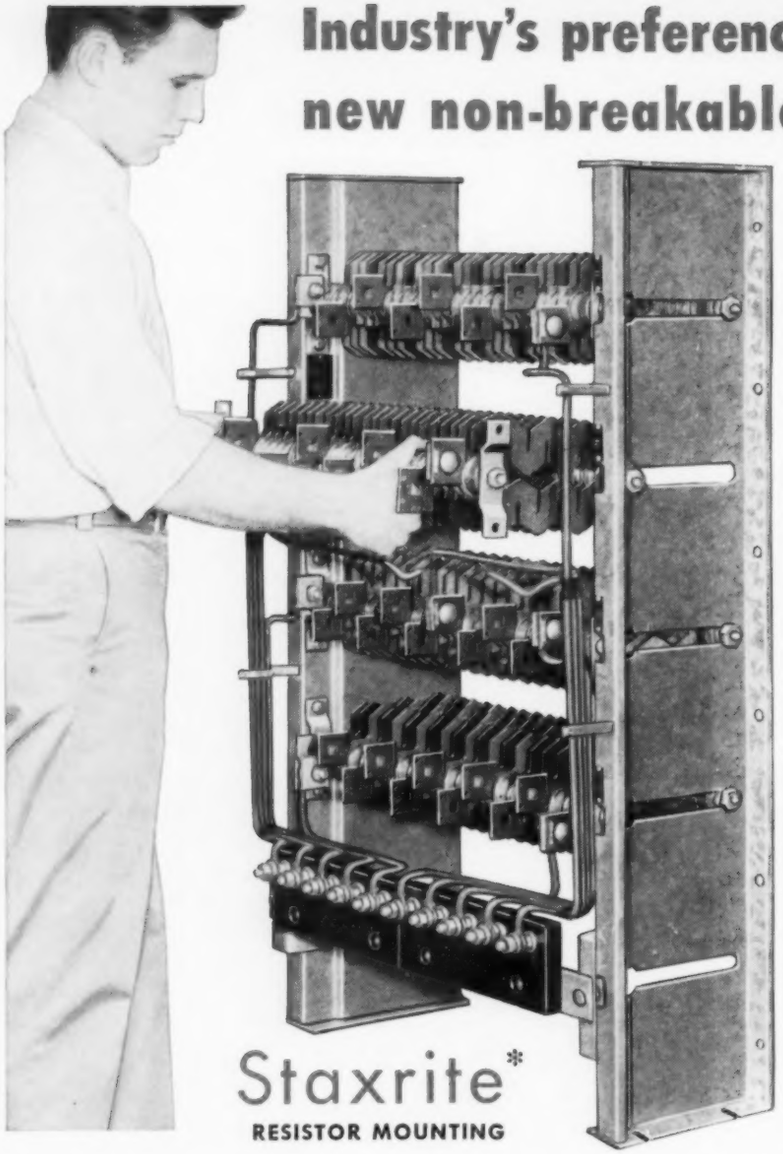
Designed and Built by MESTA

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Industry's preference... Cutler-Hammer's new non-breakable Mill Duty Resistor



Cuts costs during installation, maintenance and alterations. Exclusive C-H "Draw-out" designed resistor units slide in and out of position easily and quickly without disturbing the end frames, adjacent resistor units or mounting members. "Draw out" design cuts costly "down time" to a minimum. Any resistor can be withdrawn and replaced by a spare in a few minutes.

Difficult resistor mounting problems made easy with Staxrite. Saves valuable space ... Staxrite mounting frame, available in graduated sizes up to nine resistor units high, only requires the floor area of one resistor box. Complete terminal board wired assemblies practically eliminate costly on the job wiring. Unwired assemblies also available.

Exclusive "Draw-out" Design and Staxrite, the All New Resistor Mounting Frame, Have Made the Cutler-Hammer 11011 Mill Duty Resistors the Choice of Men Who Know

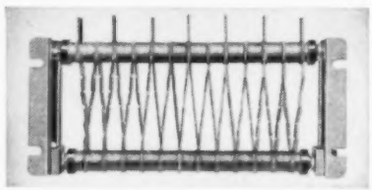
Cutler-Hammer, leading mill control designer and manufacturer for 63 years, is "first" again with "Draw-out" designed mill duty resistors and Staxrite, the multiple resistor mounting frame. Cutler-Hammer's 11011 resistor featuring exclusive "Draw-out" design, installs easier, works better and lasts longer.

The C-H 11011 resistors are non-breakable, rugged, vibration proof, and corrosion proof. Staxrite, a new concept in resistor mounting, offers new savings in space ... More resistor material for each square foot of floor area. Staxrite saves installation time. No more box-by-box mounting. For complete information on the C-H 11011 non-breakable resistor, Staxrite mounting frame and all types of mill duty control, write or wire today. Your inquiry will receive prompt attention.

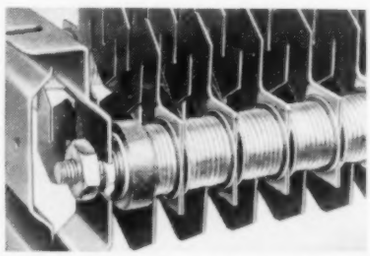
CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

*Staxrite is a Cutler-Hammer Trademark

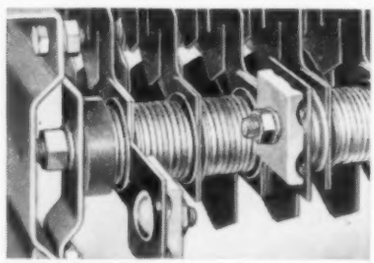
Accurate current and voltage regulation—Stamped chrome-steel grids (not cast) maintain a fixed, reliable resistance value ... a must for machinery requiring precise regulation. Shock-proof, vibration-proof, corrosion-resistant and non-breakable.



Higher current capacities—Unique "over-under" grid pattern allows wider clearance between grids for maximum air circulation and rapid, sure heat dissipation. C-H resistors work harder. C-H resistors last longer.



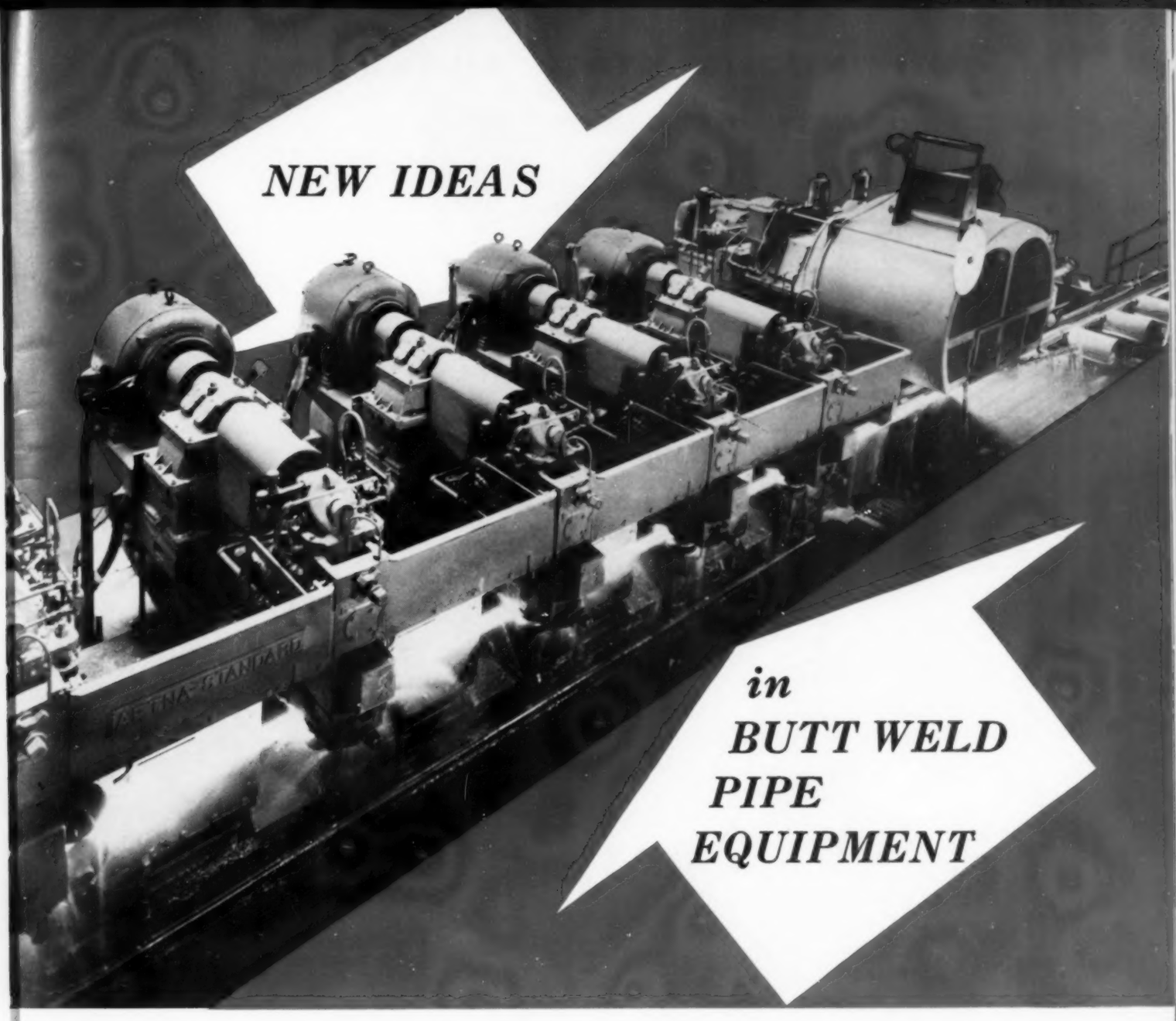
More rugged but less weight—Welded grid joints form a rugged, continuous current path. No more heavy grid tie-rods. No more pressure dependent grid contacts. Note—New floating rod construction eliminates grid stresses and distortion due to thermal expansion.



Easy to wire terminals—Hefty projected terminals are staggered for wiring simplicity. Terminal-grid weld insures positive electrical contact—can't shake loose. Note the steel spacing washers and heavy-duty mica insulators ... the mark of sturdy, rigid resistor construction.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers at 20th and Northampton Sts., Easton, Pa. Editorial and advertising offices, 1010 Empire Bldg., Pittsburgh 22, Pa. Entered as second class matter at Easton, Pa.



UNCOILER-LEVELLER . . . Equipment includes automatic handling, weighing, storage, and uncoiling of coiled skelp ahead of flash welder. One man operation. Improved leveller has skelp deflector roll, adjustable independent of leveller roll bank.

ROTARY FLYING HOT SAW . . . Saw adjustments can be made to select any cutting length without reducing delivery speed from mill. Saw adjustment permits cutting single pipe lengths from 18 feet to 60 feet.

AUTOMATIC PIPE SELECTOR releases pipe at predetermined intervals. Controls gap between consecutive lengths of pipe. Eliminates overlapping of pipes as they enter Straightener. Eliminates need for operator to regulate continuous flow of pipe.

TRAVELING CRADLES facilitate removal of crane lifts of pipe from the line of production to maintain full mill efficiency.

POSITIVE TRANSFER of pipe from Screw Type Kickoff, following Sizing Mill, to Screw Type Cooling Bed.

AETNA • STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. **PLANTS: ELLWOOD CITY, PA., WARREN, OHIO**

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

CONTINUOUS STRIP ANNEALING LINES

WHEN *Experience* COUNTS

Two of five Wean Continuous Strip Annealing Lines installed in a Pittsburgh district mill.

Ninth Wean Engineered Line Sets New Record

The ninth Wean designed continuous strip annealing line for silicon and tinplate products is now in the process of construction. This means that Wean has engineered more of these lines than all other firms combined — a record in every sense of the word.

The reasons for this Wean leadership are many. For example, the Wean design permits maximum speed and production while providing an excellent bright annealed product of uniform surface. And, users of Wean continuous lines report better metallurgical control, better temper mill operation with elimination of stickers, better delivery and a reduction in process inventory.

★ Wean also has designed and built 11 Stainless Steel Continuous Annealing Lines — also a record in the industry.

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Iron AND Steel ENGINEER

JUNE, 1957 VOLUME XXXIV NUMBER VI

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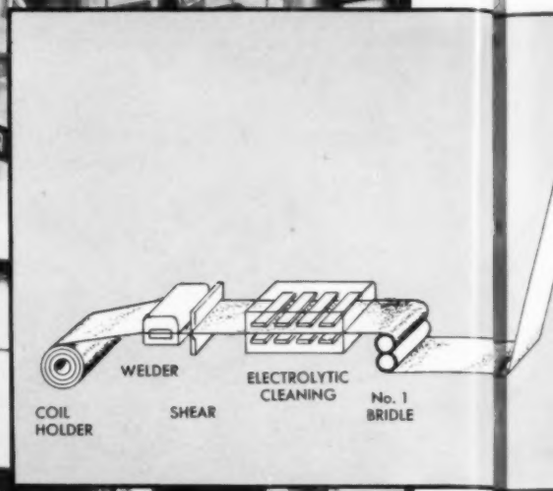
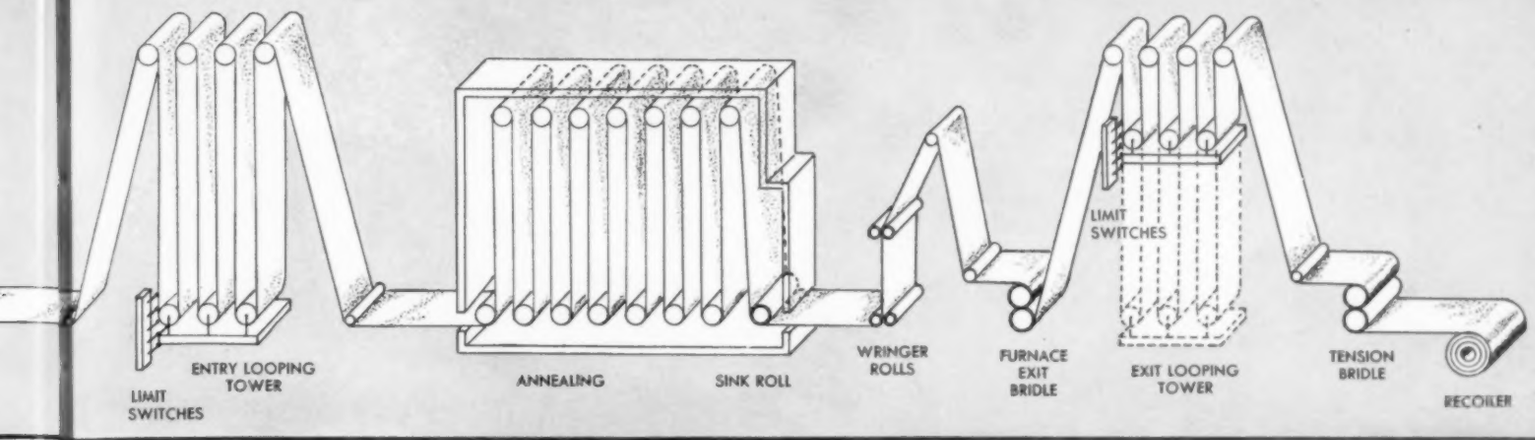


View of continuous annealing line from delivery end showing tension bridle, Clark operator's bench board, exit looping tower, cooling tower and Clark main control station.

Clark main control station for control of entire line. Various devices indicate operation of all sections from entry to delivery. Entire line can be started or stopped from this station.

CONTINUOUS ANNEALING LINE at Empire Steel relies on CLARK for precise speed and tension control • • •



Empire Steel Corporation at Mansfield, Ohio is a leading producer of high-grade silicon electrical steel. To help meet the increasing demand for this product, the corporation recently installed a modern continuous annealing line.

A vital factor in maintaining Empire's high quality for this steel is the exact control of temperature, time and tension of strip in the annealing process. Completely equipped with Clark-engineered control, the line can maintain speed of strip through the annealing section to an accuracy of better than ± 1%.

The line is designed for continuous operation at speeds up to 180 fpm, and will handle strip up to 42 inches wide, 22 gauge and lighter. Two 60-ft. looping towers, one at each end of the annealing section, provide storage for coil changes and permit the necessary speed match of entry and delivery sections to the processing section. A total of 1600 feet of strip is required to thread the line (with both looping towers full)—1300 feet are in the line under normal operating conditions.

Remotely-located control room showing main Clark control panel at left, Clark control center at right for AC auxiliaries.

The Wean Engineering Company, who furnished the line propulsion and cleaning equipment, selected Clark to design and build the controls.

Clark also furnished the synchronizing and tie-in control equipment for the annealing furnace and looping towers supplied by The Drever Company.

The **CLARK** **CONTROLLER** *Company*

Everything Under Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

How perfectly simple —this Fast's Coupling with purely mechanical flexibility!

1. A hub is keyed on each shaft. Hubs are splined at maximum distance from shaft ends.

2. Floating sleeves surround hubs. Sleeves are splined to engage hub splines.

3. Sleeves compensate for shaft misalignment by assuming neutral position between two hubs.

4. Because of distance from shaft end, any misalignment between splines is mere fraction of same misalignment between shafts.

5. Sleeves carried on bearing rings, located on *transverse center line of hub spline faces* (the load-carrying surfaces) no crank action, no vibration.

6. Lubricant is centrifugally forced into spaces between engaged splines, forming a film.

For 35 years the most positive, dependable means of coupling machines to their power source . . . Fast's Couplings have no parts subject to repeated bending, tension or compression. Because there is no metal-to-metal contact, *there is no wear*—in fact, many Fast's Couplings in use for over 30 years show no signs of wear when disassembled! No leather, plastic or rubber oil seals. Lubricant film distributes pressure over a considerable area, diminishing localized stress at pressure points on the load-carrying teeth. Perfectly simple? Yes . . . and foolproof!

For coupling catalog, technical advice or assistance from Koppers field engineers, write: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3006 Scott Street, Baltimore 3, Maryland.

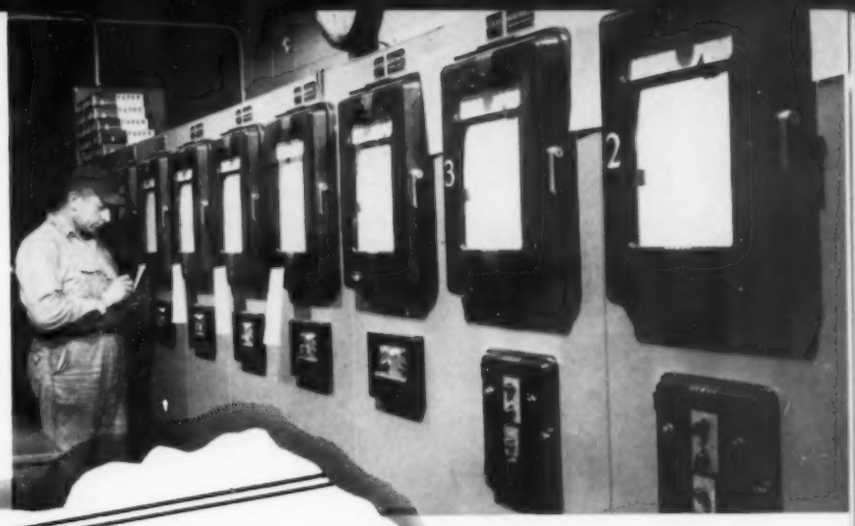
THE ORIGINAL **FAST'S Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD.
This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans.
***Engineered* Products Sold with *Service*.**

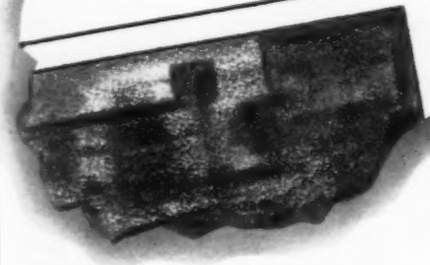
The ability of Lee Wilson engineers to work with steel mill metallurgists in the design and construction of annealing equipment for any application was reconfirmed recently when the Allegheny Ludlum Steel Corporation installed six additional Lee Wilson furnaces specially designed for annealing hot rolled stainless steels of the straight chrome variety.

Allegheny Ludlum, one of the nation's foremost stainless steel producers, wanted special furnace equipment that could withstand the stresses and strains encountered in rapid cooling.



Allegheny Triples Chrome Stainless Annealing Facility

Six More Lee Wilson Single Stack Furnaces Set into Action

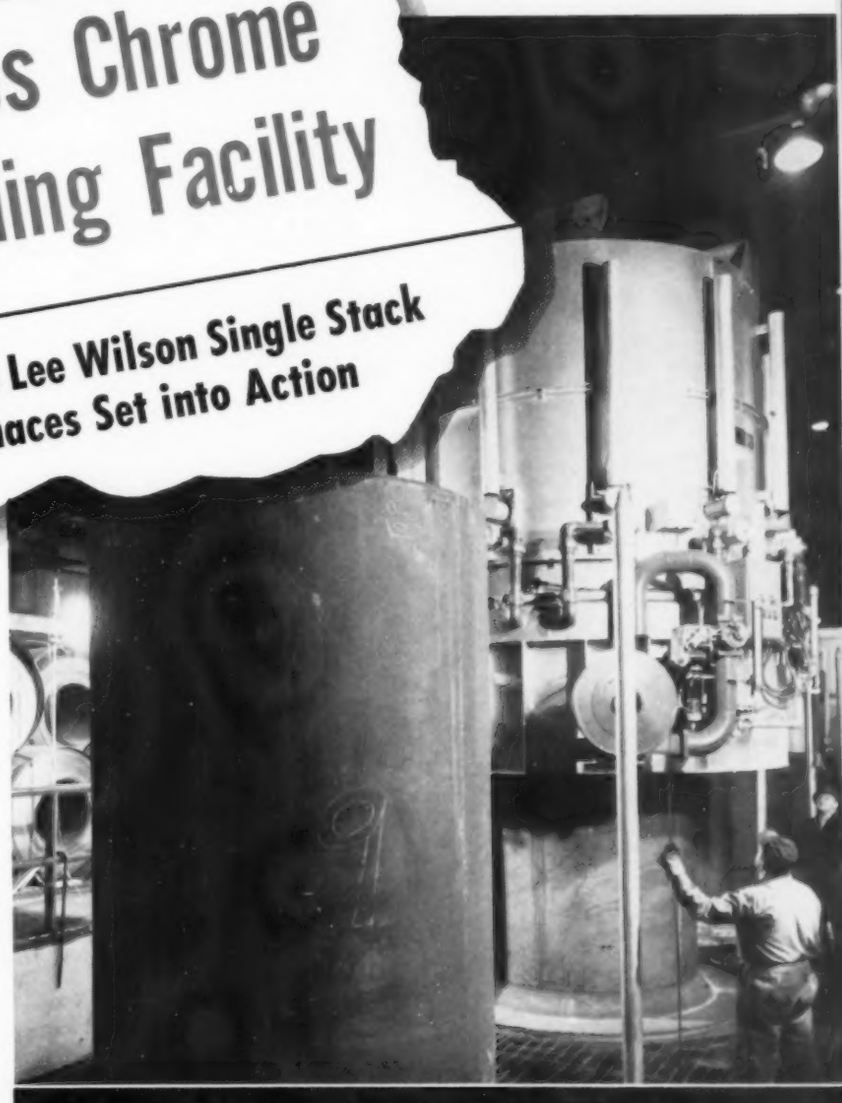


The stainless steel is brought up to a temperature of between 1525 and 1575 degrees, held for a short soak, and then both furnace and inner cover are removed. The fan is kept running. This results in an extra fast cooling.

While this fast cooling is desirable from a steel production standpoint, the rapid contraction is responsible for tremendous strains on charge supporting furnace structures and convector plates. Lee Wilson engineers developed special structures and plates that successfully withstand this extra fast contraction.

A plus advantage to fast cooling is the added production possible when the necessity for slower controlled cooling is eliminated. This, naturally, increases the production possible per base.

If you have a particular annealing problem, be sure to talk with Lee Wilson engineers before you buy. *Literature upon request.*



Allegheny's decision to purchase additional Lee Wilson furnaces was based on a thorough test. Three years ago, Allegheny installed three Lee Wilson furnaces and five bases (see left) for this highly specialized work. After considerable testing, Allegheny engineers selected the Lee Wilson Single Stack Furnace for their additional needs.

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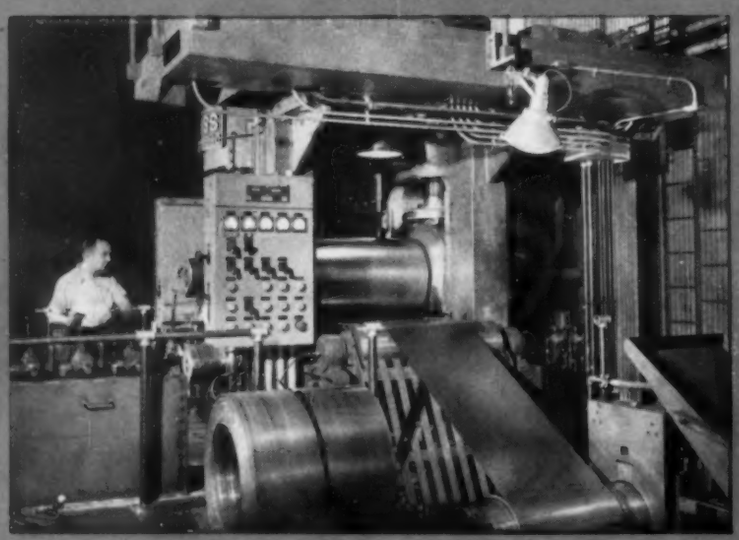
Lee Wilson* ENGINEERING COMPANY, INC.

20005 WEST LAKE ROAD • CLEVELAND 16, OHIO

SINGLE-STACK RADIANT TUBE ANNEALING FURNACES

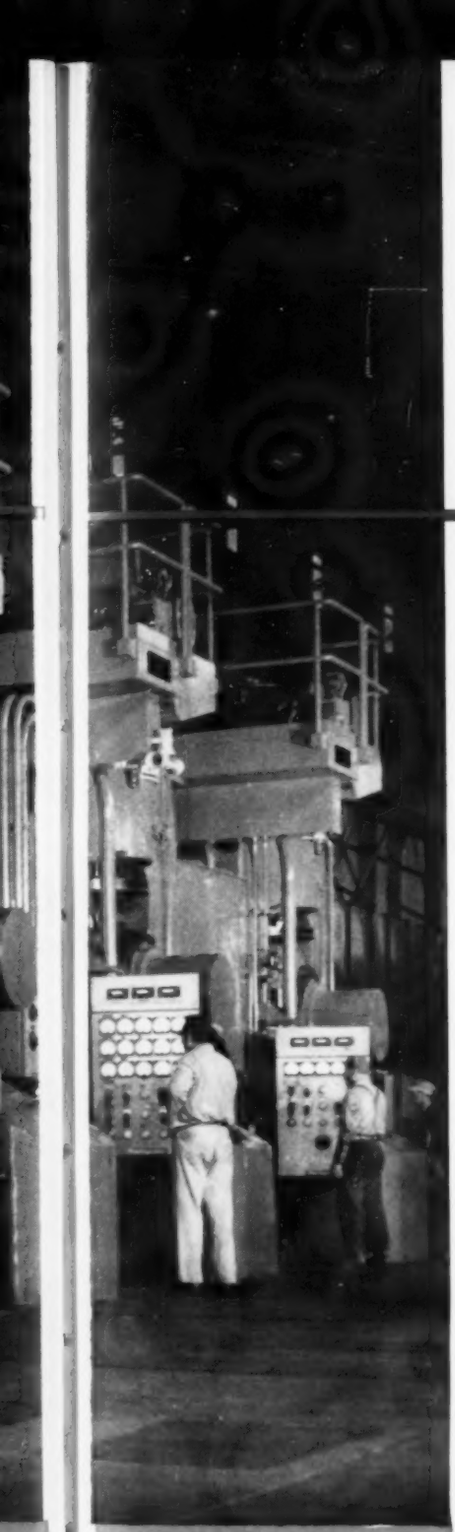
MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES



New Bliss 4-stand tandem mill at Empire Steel. Each stand is a 19" and 51" by 52" four-high mill. All entry and delivery equipment, including tension reel, coil buggy and belt wrapper were also made and installed by Bliss. Many of the rolls were supplied by Bliss' Mackintosh-Hemphill Division.

New Bliss 2-high 30" x 50" temper mill processes much of the output from the tandem. Its rated speed and coil capacity are the same as the big mill's.



Why Empire Steel picked BLISS mills for its new cold roll department...

Already known as a producer of hot rolled sheet and plate, Empire Steel Company, Mansfield, Ohio, has just completed a new cold roll department that ranks as one of the most up-to-the-minute in the country.

The key installation is a new Bliss four-stand tandem mill. Its 1866-feet-per-minute delivery speed on wide strip provides ample capacity for all Empire's foreseeable needs. A new Bliss single-stand two-high temper mill completes Empire's cold rolling facilities. Both mills are equipped with Bliss entry and delivery equipment capable of handling coils weighing up to 34,000 pounds.

Empire's selection of Bliss equipment was a logical one. Four years ago, Bliss engineered a complete hot strip mill for Empire, including the rebuilding of some existing equipment and the addition of completely new mills and accessories. The success of this modernization program had a strong influence on the company's decision to come to Bliss for its new cold rolling department.

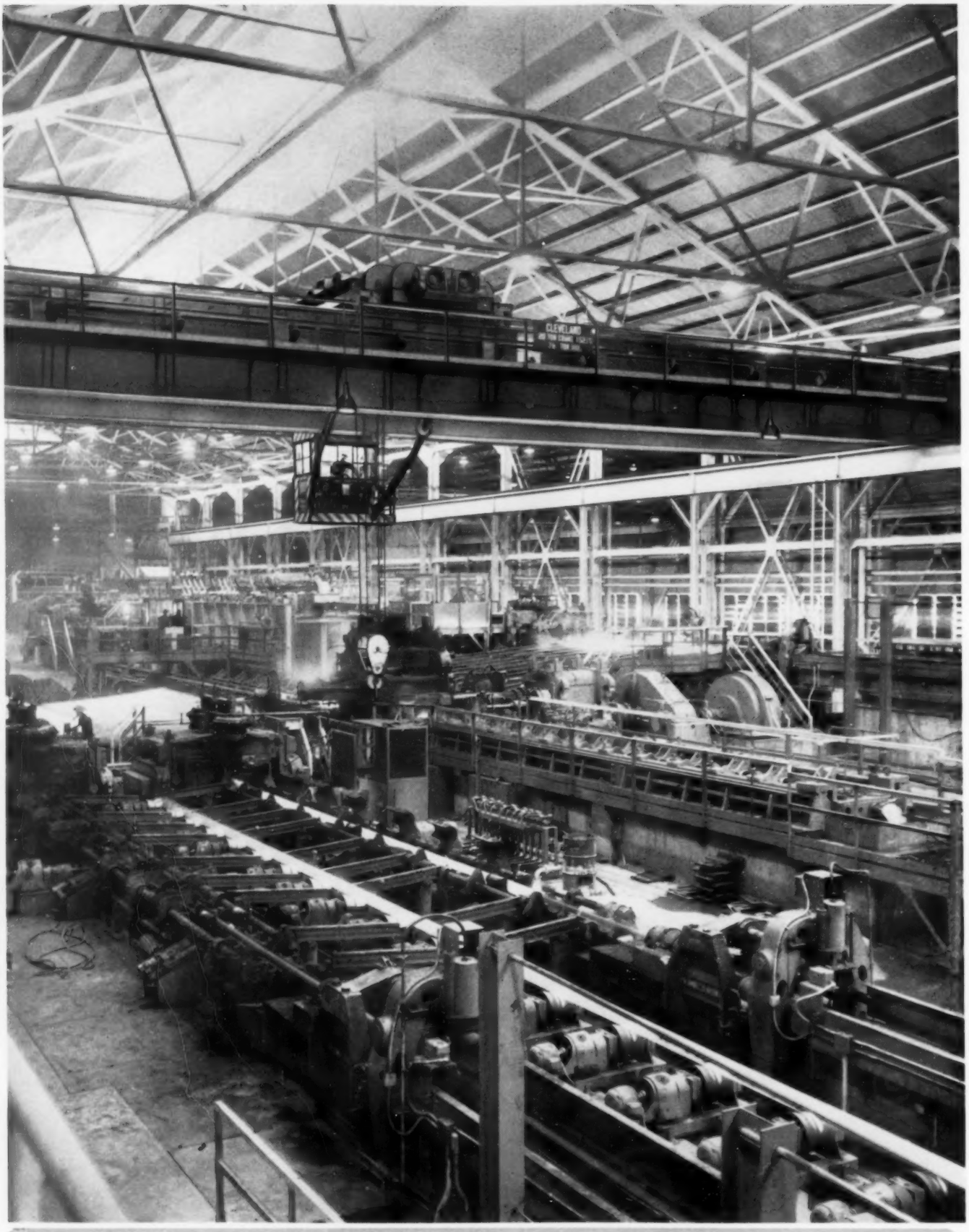
Whether you need a complete new mill or advice about modification to your existing facilities, it will pay you to discuss your problem with a Bliss engineer. To get acquainted, why not write for a free copy of our 60-page Rolling Mill Brochure, Bulletin 40-A.

BLISS
SINCE 1857

is more than a name . . . it's a guarantee

E. W. BLISS Company, General Office: Canton, Ohio
ROLLING MILL DIVISION: SALEM, OHIO

Plants at Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Midland and Pittsburgh, Pennsylvania; San Jose, California. Representatives throughout the United States.



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

IN a talk at the 65th annual meeting of the American Iron and Steel Institute, Roger Blough, board chairman of United States Steel Corporation, analyzed a bill (HR-7) which may be put before Congress at the next session. Designed primarily to force voluntary dissolution of large corporations, this bill proposes a progressive tax on corporation profits on a scale graduated from 22 per cent to 75 per cent in eight steps, to replace the present straight 52 per cent tax. The balance point in the new tax would be annual profits of $37,000,000. Below this figure, a corporation's tax would be lower than at present; above this figure, taxes would be higher.

This bill ignores completely the amount of capital that must be invested to make the profits. It ignores completely the fact that this country's safety, as well as that of our allies, depends on our industrial might. Big defense programs require big business. Taxes on the eight largest steel companies in the United States would be increased. In any business, the economies of large production would be siphoned off in taxes instead of being passed on to consumers in the form of lower prices.

Sponsors of the bill shrewdly figure that small business will favor the measure because it promises lower taxes. Large companies, far outnumbered by their smaller brethren, will be left to pick up the tab.

HR-7 is a vicious proposal. We should all familiarize ourselves with it and with the possibilities to which it might lead—and then act according to our common sense and our conscience.

▲

IN 1956, the steel industry of the United States consumed 2,261,628,763 gal of fuel oil, 419,751,675 gal of tar and pitch, 11,610,167 gal of liquid petroleum gas, 269,577,000,000 cu ft of natural gas, 849,076,000,000 cu ft of coke oven gas, 97,724,149 net tons of coal, and 35,833,000,000 kwhr of electric power. Of the electric power, 32 per cent was generated, 68 per cent purchased.

▲

FROM Washington comes this definition: "A conference is a meeting at which people talk about what they should already be doing."

▲

TWO hundred young engineers from India will be given a year's intensive training in steel production in eight of the largest steel companies in the United States. The program was set up by the Ford Foundation, the American Iron and Steel Institute, Carnegie Institute of Technology and the Indian Ministry of Iron and Steel.

THE iron and steel industry established a new safety record in 1956 with 3.83 lost time accidents per million man-hours worked.

▲

A TEXAS correspondent says the floods down there were so bad the farmers can't get through the mud to pick up their drought-relief checks.

▲

HAZEL furnace at U. S. Steel's Fairless works set a new blast furnace production record in April with 62,370 net tons of iron, an average of 2079 tons per day.

▲

ACCORDING to the American Iron and Steel Institute, there are more than 885,000 stockholders in the steel industry—more than ever before and outnumbering the 824,894 employees of the companies.

▲

SPEAKING before the National Industrial Conference Board, Robert C. Tyson, chairman of U. S. Steel's finance committee, said: "Our new kind of inflation appears to be cost inflation pushing prices up rather than price inflation pulling up costs through competitive bidding for materials and manpower. We might think of it as a new cost-push type as distinguished from the conventional demand-pull type of inflation." He mentioned that wage inflation encouraged by powerful labor unions has come about with "frightening speed," and is surprisingly universal and uniform, with almost complete insensitivity to economic forces.

▲

ACCORDING to Goodyear Tire & Rubber Co., Morin Plenty, who claims to have invented a rubber heel round in shape and adjustable so that it can be rotated as one point wears, is infringing on a 1914 patent. The company states the original idea was developed by its English subsidiary, which is currently selling some 5000 pairs of rotating heels in England.

In case you don't follow the comic strips, Morin Plenty is a current character in the Dick Tracy strip, created by Chester Gould.

▲

THE metal container industry is now a $1,600,000,000-a-year business. Output has increased some 60 per cent in the past ten years. The industry now employs about 55,000 people and has an annual payroll of about $289,000,000.

▲

KEITH GLENAN, president of Case Institute of Technology, says that 50 to 75 per cent of the work being done in engineering departments of manufacturing plants can be done as well, if not better, by engineering technicians who graduate from two-year technical colleges rather than from four-year universities.

▲

DURING 1956, 40,000 Americans were killed and 2,368,000 injured on our highways, an increase of six per cent in fatalities and nearly ten per cent in injuries over the 1955 figures.

▲

THE struggle to make ends meet begins in the cradle when the infant tries to get his toes in his mouth.

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OXWELD C-62 Blowpipe—fast,
efficient, economical.

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Powder-washing is the fastest, most efficient way to remove fins, pads, sand inclusions, and other defects from casting surfaces.

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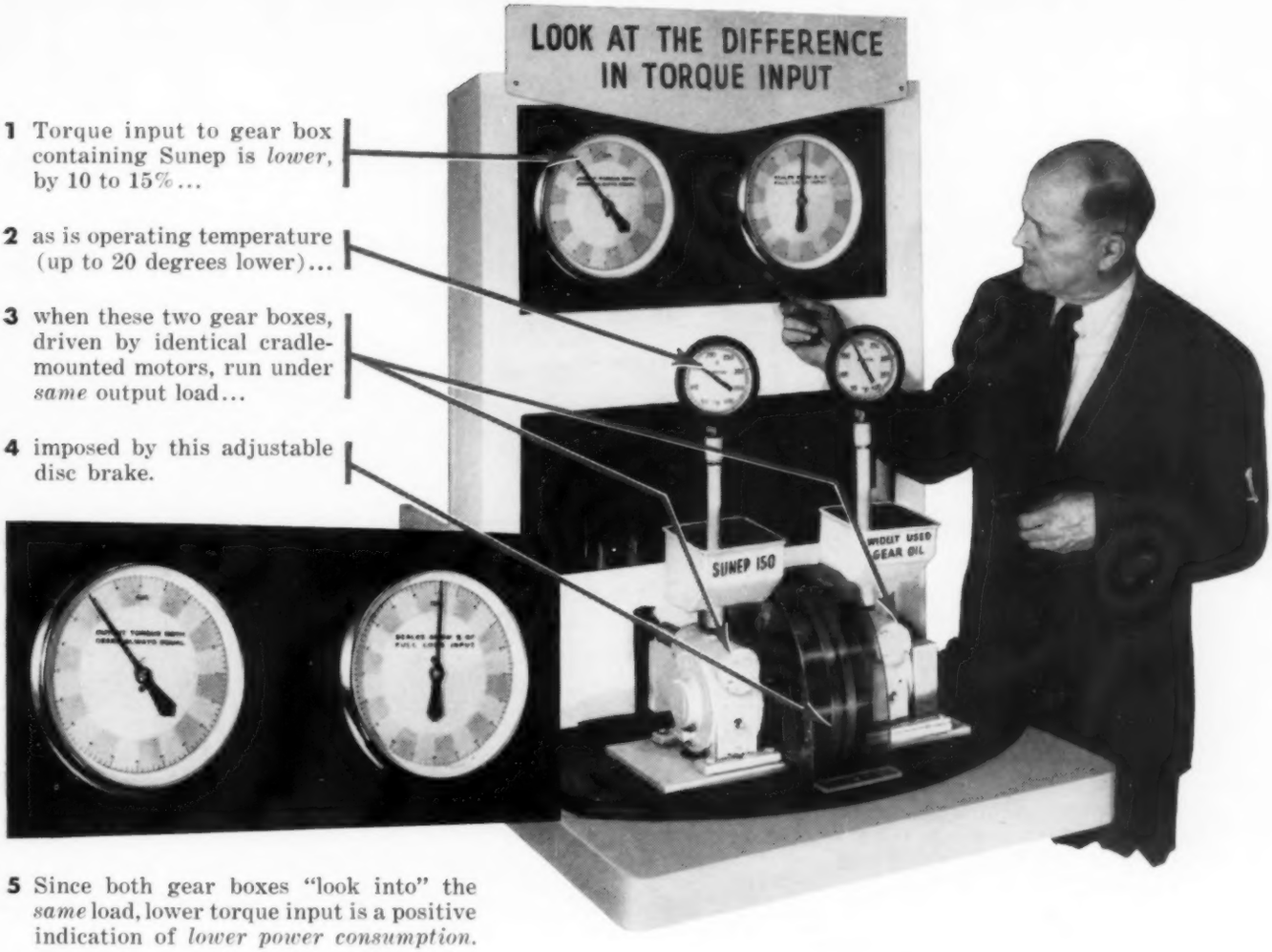
LOOK AT THE DIFFERENCE IN TORQUE INPUT
1 Torque input to gear box containing Sunep is *lower*, by 10 to 15%...
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TIME AND AGAIN, under equal operating conditions, Sunep® gear lubricant has demonstrated its superiority over competitive oils. Sunep is a high-quality, extreme-pressure lubricant that is also recommended for screws and heavily loaded bearings.

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KOPPERS

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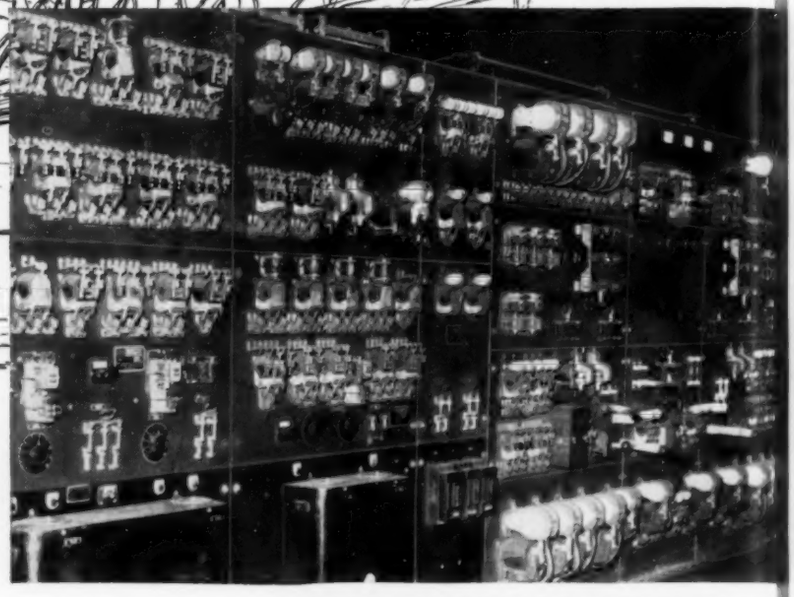
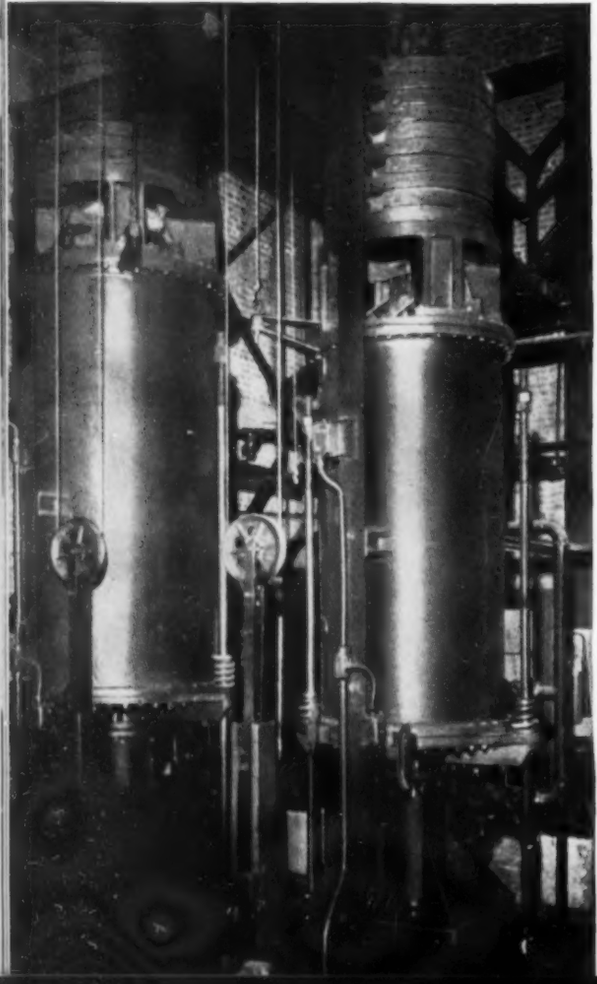
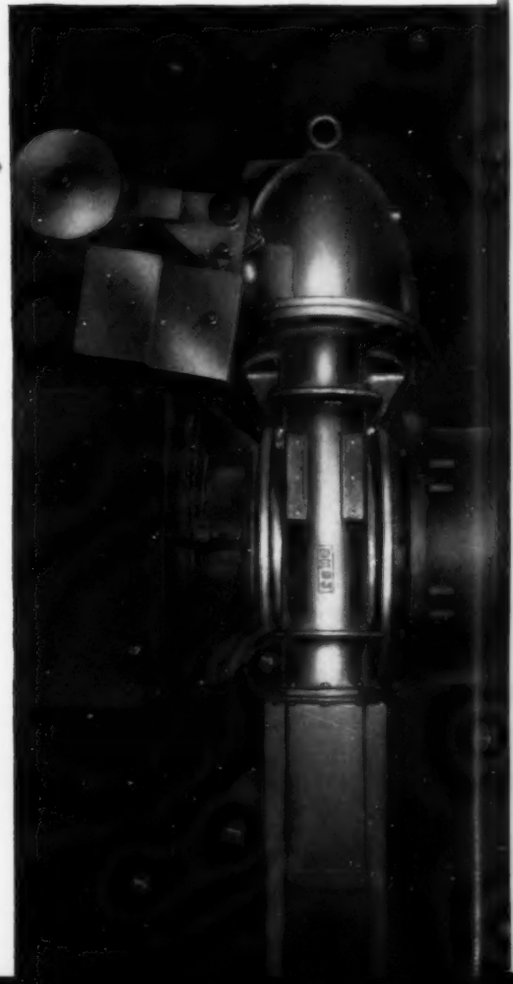


Freyn-Design Automatic Charging & Skip Hoist Control provides maximum production at lowest cost. It combines built-in precision for safe, accurate operation, with extra ruggedness for dependable, trouble-free service.



Freyn-Jansen Burner Shut-Off Valve replaces the conventional burner door in hot blast stove installations. It increases the speed and safety of burner changing operations, eliminates refractory and gasket maintenance.



Freyn-Design Pneumatic Bell Hoist Is engineered to provide long life with little maintenance. It uses cold blast air—the least expensive, most dependable operating power at the blast furnace.

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There are many sound reasons for Freyn's continued leadership in the design and construction of equipment for blast furnace operations. Freyn provides the *most complete* line of blast furnace equipment. And blast furnace operators throughout the world *know* that with Freyn equipment they get these important advantages:

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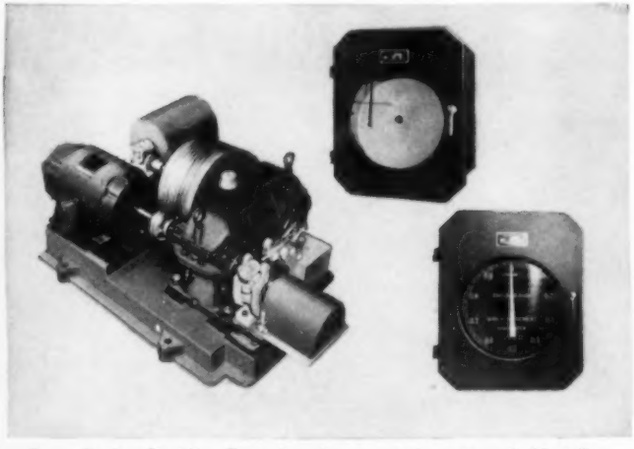
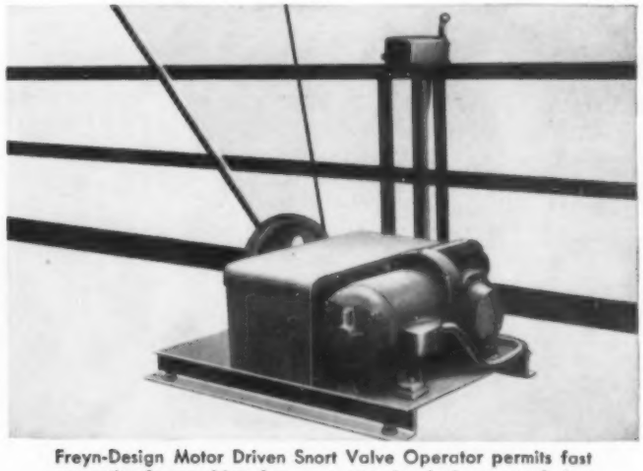
Investigate the long range reliability and economy of Freyn-Design blast furnace equipment for your operations. Send for information on Freyn equipment or consult our engineers. **Freyn Department, Koppers Company, Inc., Pittsburgh 19, Pa.**



Freyn-Design Stockline Recorder gives accurate, automatic blast furnace stock level measurement: winch mechanism hoists and lowers test rod, actuates indicating and recording devices; recording meter records actual stock level on chart; stock movement visualizer magnifies and indicates frequency of burden movement; lamp target indicator shows stock level at all times, mounts in stock and/or cast house.



Freyn-Design Motor Driven Snort Valve Operator permits fast operation for any blast furnace snort valve. In the event of electrical power failure, the manual handwheel becomes operative immediately.

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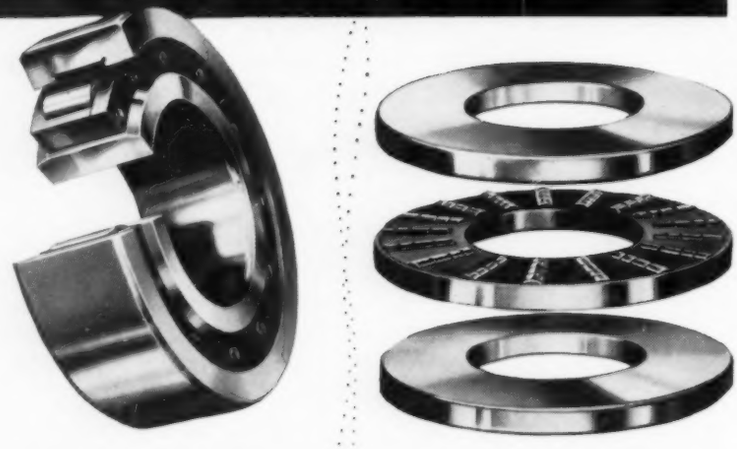

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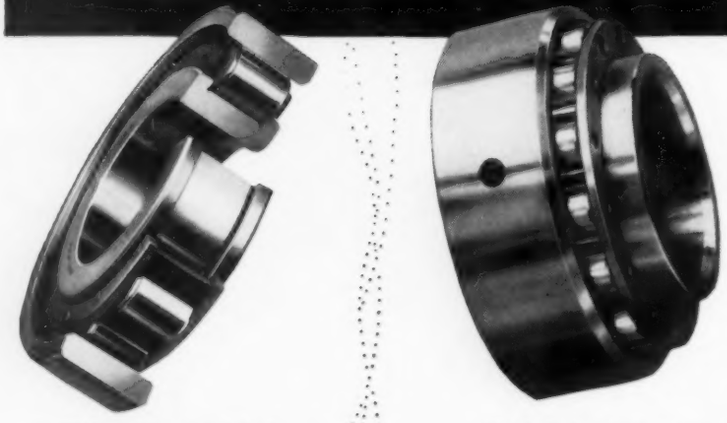

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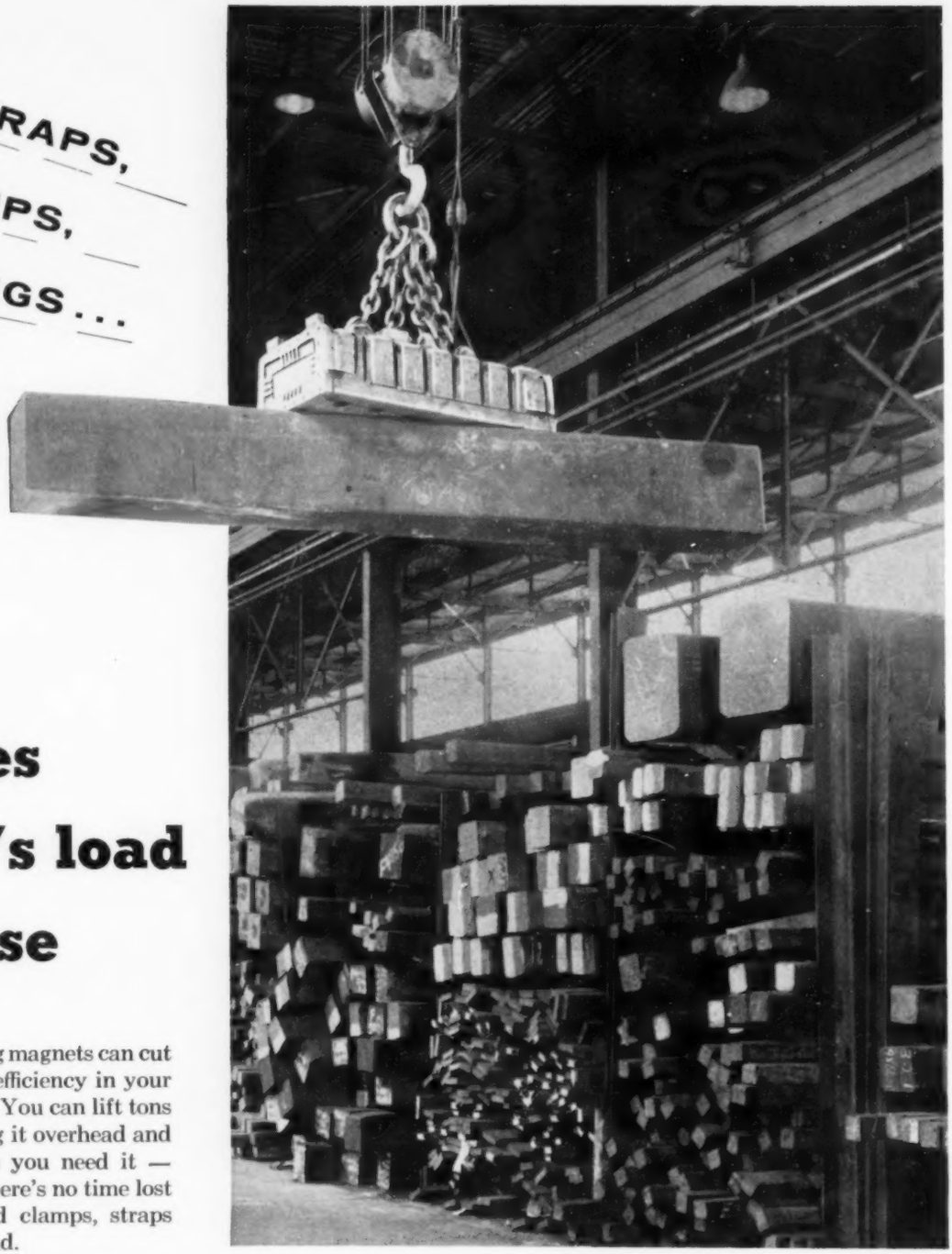

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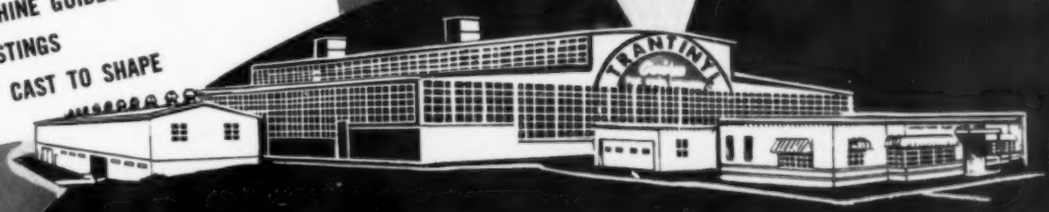
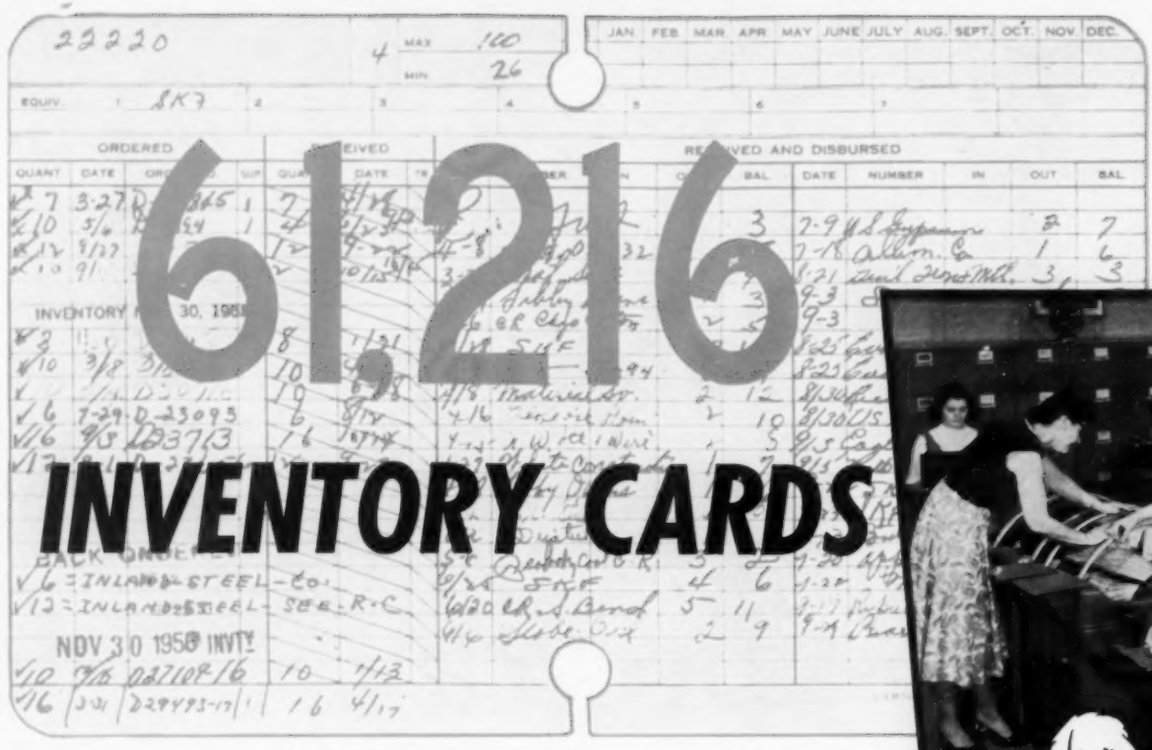
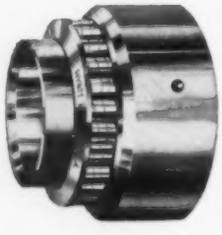


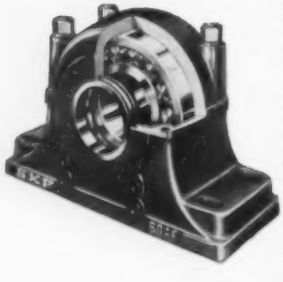
Youngstown Alloy Casting Corporation

Youngstown, Ohio

61,216 INVENTORY CARDS







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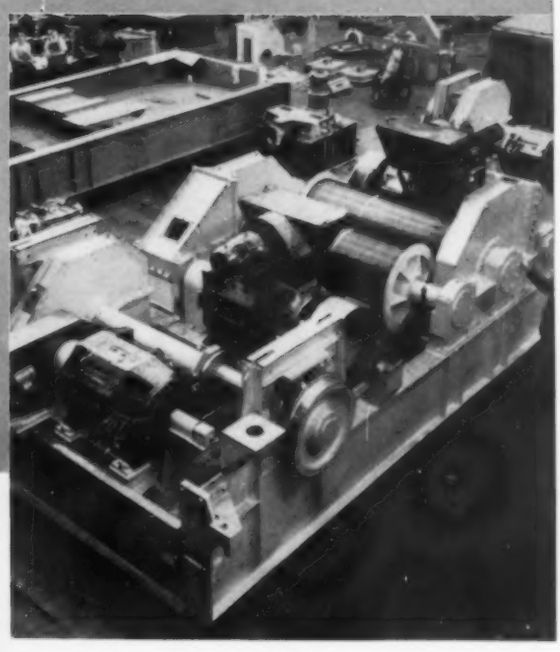

Shop Assembly of Welded Man Trolley—accurate alignment is always assured as welds will not loosen. All connections are sealed, maintenance is simplified and hidden corrosion avoided.

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welded construction used to assure strength and rigidity

The use of welded construction at key points is one of the many features which add to the life and usefulness of Dravo bulk materials handling equipment. Many other operating economies result from the fact that each structure is individually designed to handle its specific job economically, dependably and safely. Such performance is achieved by bringing together the customer's operating knowledge and the experience of Dravo's research, design and construction men.

This method has resulted in high efficiency unloaders and other bulk materials handling equipment that produce because they are tailored to fit the job. Dravo engineering features, built into every structure, provide for low maintenance and operating costs. For complete information write to Dravo Corporation, Pittsburgh 25, Pa.

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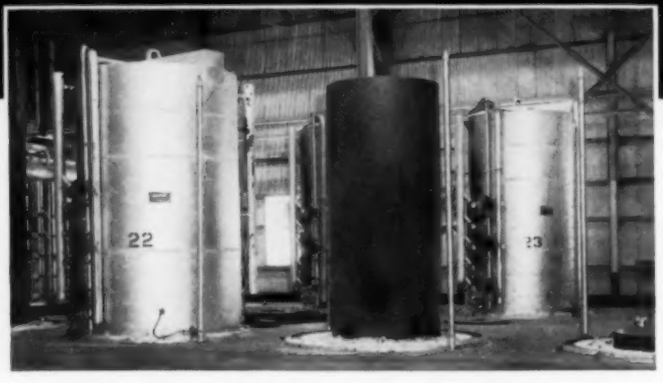
"Curved-Tube" assembly for single-stack annealer, centrifugally cast of Thermalloy high-heat-resistant alloy.



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ELECTRO-ALLOYS DIVISION Elyria, Ohio

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period January 1, 1957 through January 22, 1957 . . . .

TREATMENT OF IRON ORES

▲U. S. 2,776,207, issued Jan. 1, 1957 to Edgar B. Mancke, assigned to Bethlehem Steel Co., relates to a method of removing nickel, cobalt, and chromium from Mayari iron ores.

Mayari ores are solubilized with a sulphate, and the sulphate solution is subjected to an autoclave treatment, yielding an iron ore product low in nickel, cobalt, and chromium. The sulphate solution may be prepared by roasting the ore and then leaching with sulphuric acid, or by roasting the ore with ammonium sulphate, followed by a water or sulphuric acid leach. Upon autoclaving the solution, an iron product of basic iron sulphate is precipitated, containing less than 0.10 per cent nickel or cobalt, with a chromium content down as low as 0.15 per cent.

APPARATUS FOR QUENCHING PIPE

▲U. S. 2,776,230, issued Jan. 1, 1957 to James A. Scott and assigned to United States Steel Corp., describes an apparatus for quenching pipe progressively along its length, to provide the increased strength needed for casings in wells of 15,000 ft in depth. In this type of heat treatment, the quenching zone must be immediately adjacent the heating furnace in order to prevent excessive atmospheric cooling and insure quenching at the rate necessary to produce a martensitic structure.

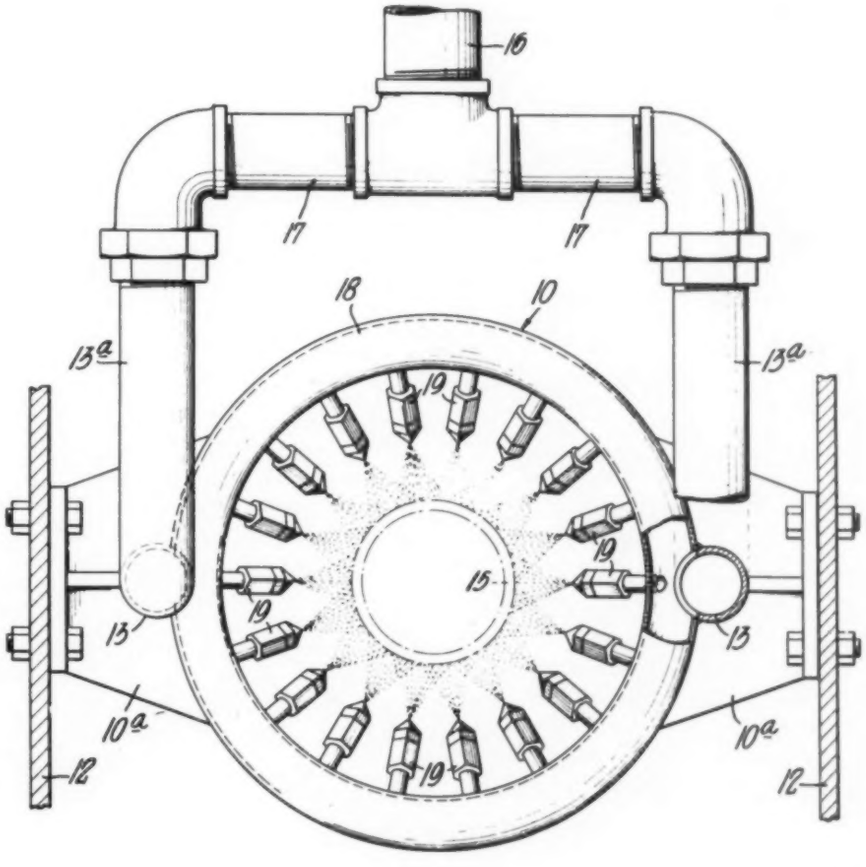
The apparatus is shown in Figures 1 and 2. The quenching apparatus 10 is arranged coaxially of and close to the exit end of a continuous pipe-heating furnace 11, and supported on splash plates 12. The apparatus includes a pair of tubular headers 13, parallel to the pipe 15. Water is supplied through a main 16 and branch pipes 17. A number of nozzle rings 18, fitted with nozzles 19, spray the water onto the moving pipe as shown. The nozzle tips are located far enough from the pipe to insure that all the water breaks into droplets before striking the pipe.

Figure 3 shows cooling curves for the inside and outside surfaces of the pipe. The cooling rate is such as to cause conversion of the greater portion of the steel to a martensitic structure.

SMELTING IRON WITH MOBILE FUELS

▲U. S. 2,776,883, issued Jan. 8, 1957 to William E. Marshall and Samuel A. Bell, assigned to Armco Steel Corp., describes an apparatus for smelting iron with mobile fuels, i.e., gas, oil, or pulverized coal or coke. The patent relates to the melting and carburization steps—

Figure 1



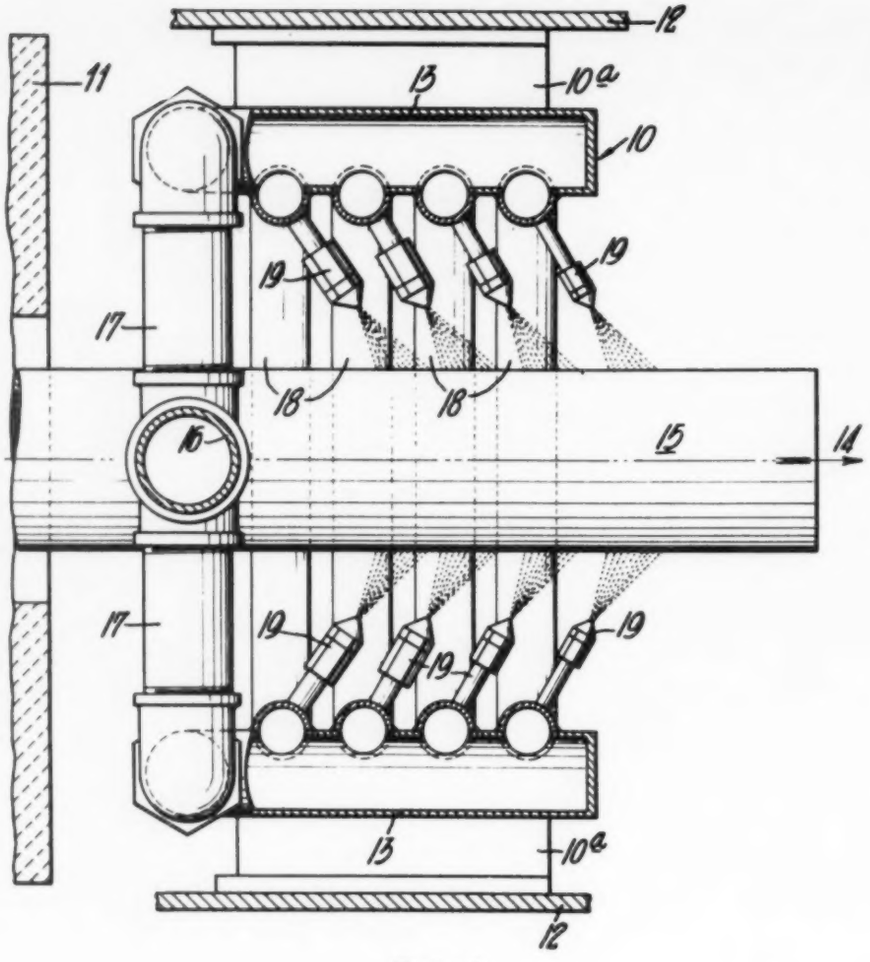


Figure 2

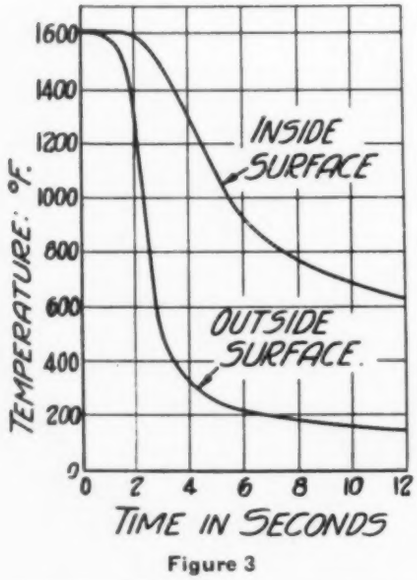
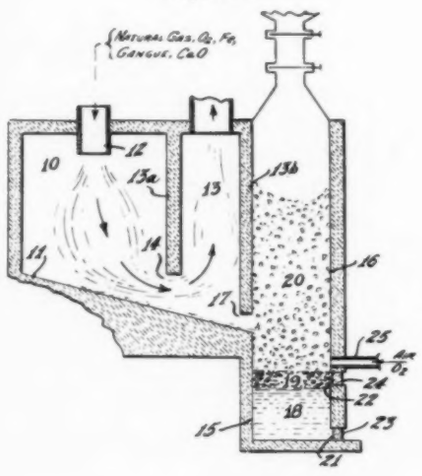


Figure 3

the reduction being carried out in other apparatus.

As shown in Figure 4, a combustion chamber 10 is provided with a sloping floor 11. A burner 12 is also provided, into which are fed the mobile fuel, oxygen or oxygen-enriched air, finely divided reduced iron ore, gangue, and CaO. The fuel burns in the combustion chamber 10, and the products of combustion pass through stack 13, while the slag-forming constituents and the iron melt and collect on the floor 11. A collecting hearth is indicated at 15 and is provided with a coke-containing chamber 16. The bath of molten iron is indicated at 18, the slag layer at 19, and the coke at 20. A tap hole for the iron is provided at 21 and a tap hole

Figure 4



for slag at 22. Oxygen or oxygen-enriched air is fed to the coke column through duct 25, burning some coke in order to maintain the bath in molten condition. Very little air or oxygen is required in duct 25.

Whereas a conventional blast furnace consumes about 1800 pounds of coke per ton of iron produced, the present apparatus uses substantially just enough coke to saturate the iron with carbon.

METHOD OF CONTROLLING THE FORMATION OF CRYSTALS IN MOLTEN METAL AS IT SOLIDIFIES

▲U. S. 2,778,079, issued Jan. 22, 1957 to Dennis J. Carney and Bernard R. Queneau, assigned to United States Steel Corp., describes a method for improving the quality of metal ingots by controlling crystal formation on freezing.

The invention is based on the provision of nuclei in the molten metal, each of which favors the formation of a crystal around it. The seeding is accomplished with solid metal particles having a space lattice similar to that of the metal of the bath at its solidification temperature or a crystallographic plane in common with it, and substantially the same space-lattice parameter.

For steel crystallizing in a body-centered cubic system, such as ordinary carbon steel, the powdered metal added may be chromium, iron or molybdenum, or alloys thereof. Metals forming a face-centered cubic system, such as 18–8 stainless steels, may be treated by the addition of powdered nickel, iron, cobalt, or manganese and the austenitic alloys thereof.

PROCESS FOR HARDENING STEEL

▲U. S. 2,778,756, issued Jan. 22, 1957 to Nikolajs Bredzs, describes a process for hardening plain carbon steel containing 0.3 to 1.0 per cent carbon, to achieve a uniform martensitic structure with a low rate of cooling.

As shown in Figure 5, the process is carried out in a mold 10. A cover plate 13 fits closely within the mold.

A steel article 14 is placed in the mold with the cover 13 on top of it. The mold and article are subjected to a temperature of 1500 F. until

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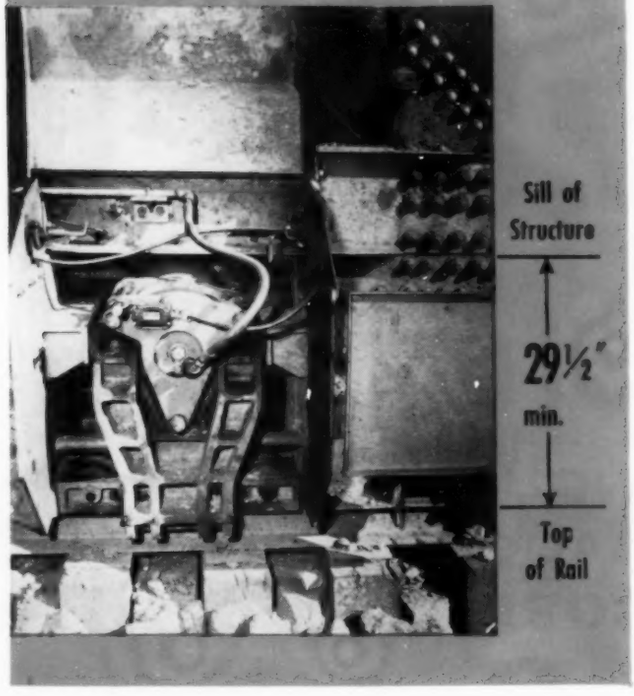
provide *new advances* in safety...economy...reliability

This rail clamp can be installed under the sills of most bridges or towers



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INFRA-RAY WIDTH GAUGES for hot strip.

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WEIGHT INTEGRATORS for conveyor belts.

INFRA-RAY RELAYS—for automatic actuation.

LOAD RELAYS—Sensitive and easily adjusted.

The Youngstown Sheet and Tube Company* delivers sheets of closer tolerance because XactRAYMATIC Systems now automatically classify already-sheared tin plate sheets of any length at rates of 60 to 100 per minute.

Youngstown's Reclassifier Lines are equipped with XactRAY Gauges and XactRAYMATIC Control Systems to automatically sort these sheets by thickness during the inspection-assorting process—Youngstown's latest application of our XactRAY Gauges.

Repeat orders are proof of profitable installations.

Your own automation problem may be different . . . But we know the steel business and know where XactRAY Systems will work. Why not talk it over with us.

*Indiana Harbor Works

Write

OR TELEPHONE TEaneck 3-1400

I G C

INDUSTRIAL GAUGES CORPORATION

WEST ENGLEWOOD NEW JERSEY

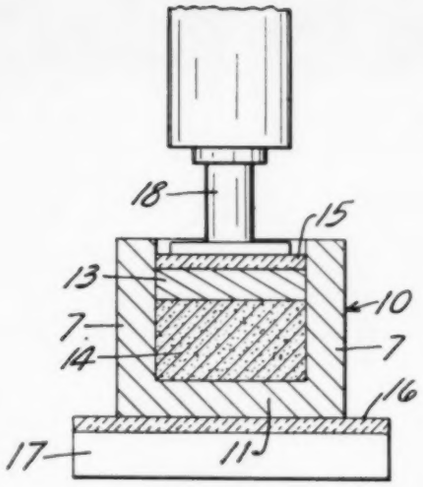


Figure 5

the temperature is uniform throughout. A heat insulating member 15 is then placed on the cover 13 and another insulating member 16 is placed below the mold 10. The assembly is then placed between converging compression members 17 and 18, until a pressure of 18 to 20 tons per sq cm is reached. The mold is then allowed to cool by standing at ordinary room temperature under this same pressure.

According to the inventor, pearlite formation is minimized or avoided irrespective of the cooling rate, when such a pressure is applied. No skin casing forms around the article during the hardening process.

PRODUCTION OF HIGH PURITY IRON IN A VACUUM FURNACE

▲U. S. 2,776,204, issued Jan. 1, 1957 to James H. Moore, assigned to National Research Corp., describes a vacuum process for the production of very high purity iron containing less than 0.015 per cent oxygen using relatively inexpensive crucibles.

An excess of carbon over oxygen is added to the charge. The furnace is then pumped down to 0.001 mm and the charge is heated to 1650 C. As carbon monoxide forms, the pressure rises. As the rate of carbon monoxide begins eventually to decrease, the pressure in the system also falls. When the carbon and oxygen in solution get quite low, there comes a point beyond which the carbon has reduced the oxygen in solution to so low a value that diffusion in the boundary layer next to the crucible, and subsequent distribution of oxygen by molten currents, becomes more dominant than the deoxidation effect of the carbon. The oxygen content of the melt then begins to rise in a relatively rapid approach toward equilibrium with the crucible material, as shown in Figure 6.

As shown in Figure 7, in which the rate of decrease of CO concentration with time is plotted against oxygen concentration, the approach to the minimum oxygen concentration is marked by a rapid decrease in the rate of evolution of carbon monoxide. Thus, when the CO evolution rate reaches 4 to 20 micron cfm per pound of iron, the reaction is arrested by pouring the charge from the crucible into a mold, or by flooding the vacuum furnace with an inert gas such as argon.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,775,825	1/1/57	Apparatus for treating a strip of metal	Surface Combustion Corp.
2,776,021	1/1/57	Apparatus for naphthalene absorption	Koppers Co., Inc.
2,776,128	1/1/57	Forge furnace	Surface Combustion Corp.
2,776,130	1/1/57	Air preheater for melting furnaces	Reda Pump Co.
2,776,134	1/1/57	Heat treating apparatus	Surface Combustion Corp.
2,776,206	1/1/57	Method of adding magnesium to molten cast iron	The International Nickel Co., Inc.
2,776,208	1/1/57	Welding rods for hard facing alloys	American Brake Shoe Co.
2,776,474	1/8/57	Method of continuously producing welded pipe	Fredrich Kocks, G.m.b.H.
2,776,585	1/8/57	Ring forming mill	Edgar H. Kendall
2,776,586	1/8/57	Construction and control of cold rolling mills	Armzen Co.
2,776,710	1/8/57	Apparatus for longitudinally slitting strip	Youngstown Industries, Inc.
2,776,764	1/8/57	Apparatus for handling coil strip material	A. J. Gerrard & Co.
2,776,827	1/8/57	Method of alternate low and high fuel firing of a soaking pit furnace	Amsler Morton Corp.
2,776,874	1/8/57	Reactor for the high temperature reduction of iron oxide	Republic Steel Corp.
2,776,882	1/8/57	Decarburizing high-carbon ferrochromium	Union Carbide & Carbon Corp.
2,776,885	1/8/57	Production of ferrosilicon	Stamicarbon N.V.
2,776,939	1/8/57	Continuous electrotinning	Jones & Laughlin Steel Corp.
2,777,587	1/15/57	Displaceable billet support for rotary peeler	United States Steel Corp.
2,777,647	1/15/57	Coil unreeler	Acme Steel Co.
2,777,684	1/15/57	Heat treating apparatus	Vernon H. Ferguson
2,777,755	1/15/57	Treatment of iron ores for the separation of gangue and nonferrous metals	Bethlehem Steel Co.
2,777,808	1/15/57	Regenerative coke oven battery	Koppers Co., Inc.
2,777,936	1/15/57	Making bimetallic billet	Superior Steel Corp.
2,778,101	1/22/57	Forging artillery shells	Arthur E. Dullum
2,778,731	1/22/57	Corrosion-resistant austenitic steel not requiring nickel	United States Steel Corp.
2,778,732	1/22/57	Boron-containing ferrosilicon	Union Carbide & Carbon Corp.
2,778,755	1/22/57	Controlled cooling of steel forgings	Kropp Forge Co.
2,778,783	1/22/57	Prevention of coke oven buckstays from overheating	Carl Otto
2,778,784-5	1/22/57	Self-sealing coke oven doors	Carl Otto

Figure 6

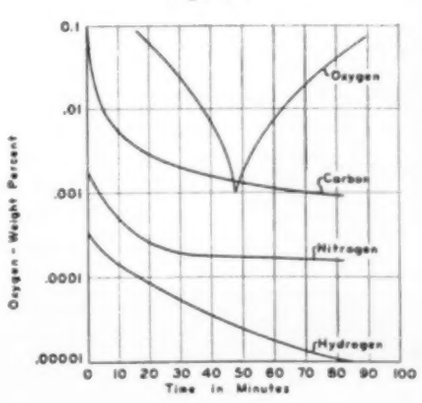
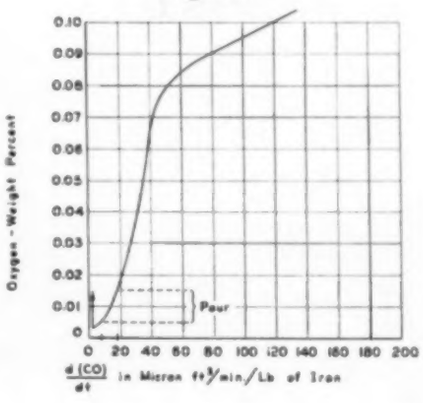


Figure 7



"...the most return, dollar for dollar, on our investment"

says RALPH SCULLY, Plant Engineer,
Grinnell Corporation, Cranston, R.I.

Pangborn Continuous-Flo® Barrels pay for themselves in short time at Grinnell

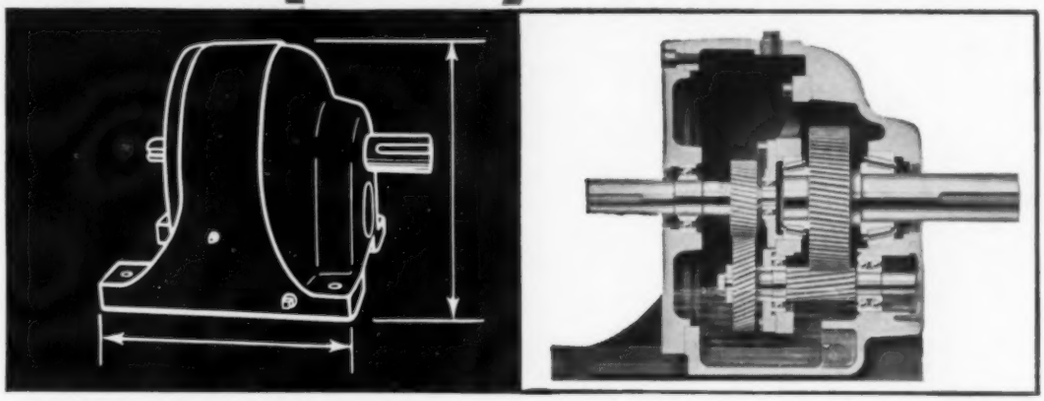
In the manufacture of its quality pipe fittings and pipe hangers, Grinnell Corporation cleans thousands of castings daily in its foundries at Cranston, R.I., and Columbia, Pa. To do this effectively and economically proved a problem. "We investigated all types of cleaning equipment," says Mr. Scully, "and decided the Pangborn Continuous-Flo Barrel lent itself best to our production situation and would give us the most return, dollar for dollar, on our investment. We installed Continuous-Flo Barrels and have been pleased with their performance. Based on continuous operation, cost savings indicate they will pay for themselves in a relatively short time."

If you have an unusual cleaning problem, Pangborn offers a special service. Pangborn engineers will study your problem and its relation to your production line. Then they will design a machine for your particular needs. Find out now how Pangborn's engineering service can give you better cleaning and faster production at lower cost.

Write today for Bulletin 1210 to PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Maryland. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

Pangborn blast cleans cheaper

NEW compactness outside . . .
NEW simplicity inside . . .



MINIMIZED SPACE REQUIREMENTS and easier layouts result from location of input and output shafts in same horizontal and vertical planes.

ONE LOW-SPEED GEAR SET per drive size and maximum accessibility of all operating parts simplify servicing and ratio changes.

. . . and built for smoother speed reduction *all the way around*

NOW! *LINK-BELT In-Line Helical Gear Drives* immediately available from stocks near you

With these new in-line helical gear drives, Link-Belt offers you a high degree of simplicity and standardization never before achieved in speed reducers. In terms of your production efficiency, it means less and simpler servicing . . . maximum life . . . quick, convenient ratio changes.

Link-Belt also makes an outstanding line of heavy-duty parallel shaft gear drives that cover a wider ratio range up to 300 to 1 and horsepowers to 2000.

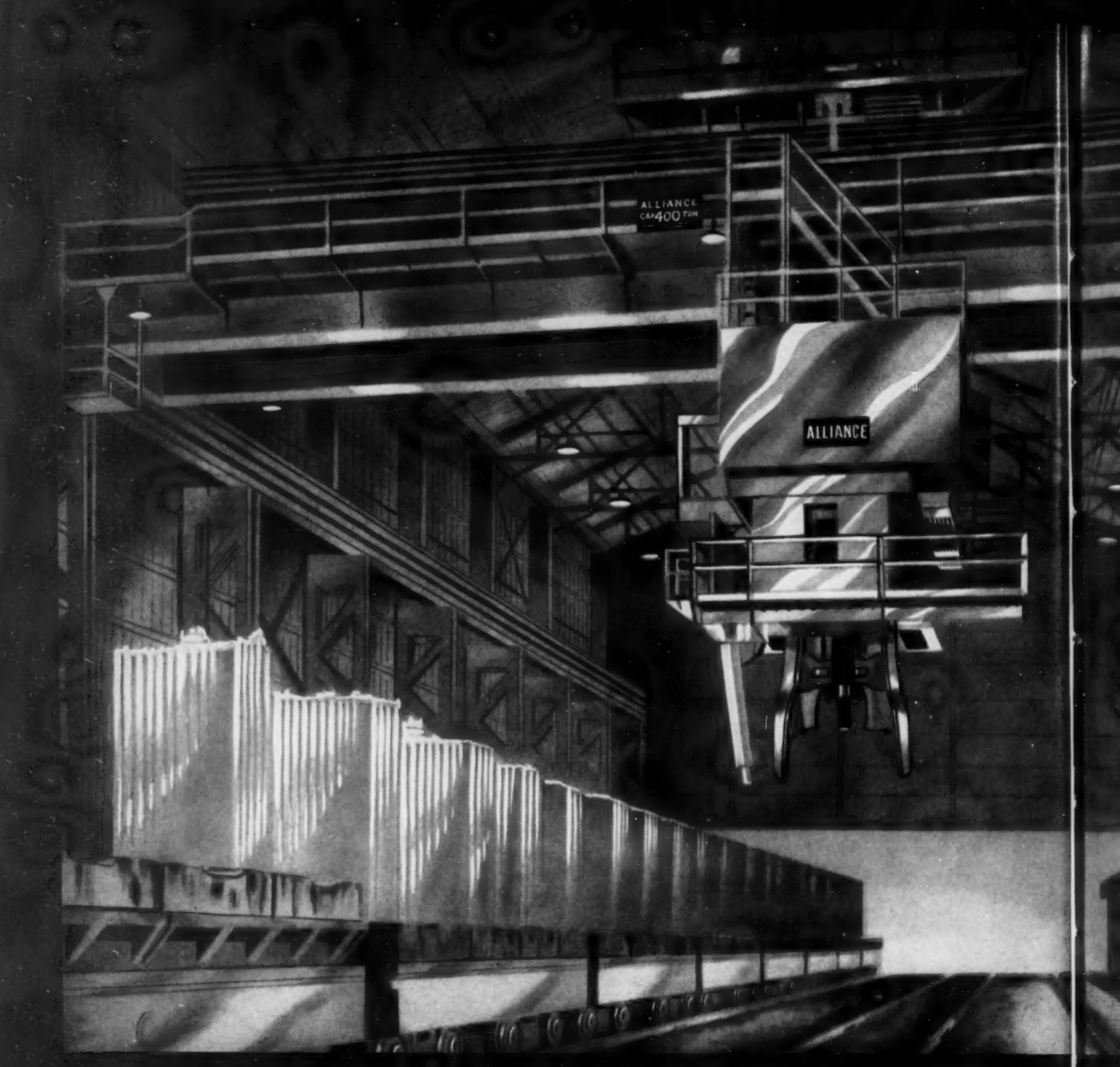
Get full information on Link-Belt In-Line Helical Gear Drives from Book 2651 . . . on parallel shaft drives from Book 2619. Ask your nearest Link-Belt office or authorized stock-carrying distributor.

Available with double or triple gear reductions . . . ratios 6.2:1 to 292:1 . . . capacities to 118 hp. Conform dimensionally with new NEMA motor sizes.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,319



THE WORLD'S LARGEST STRIPPER CRANE

• This 400-ton Alliance push-pull Stripper Crane is the world's largest. It can exert 2,400,000 pounds' pressure to strip moulds from ingots — cleanly and safely. The patented Impact Stool Loosener speeds up the stripping operation. The stripping mechanization has a nominal rating of 400 tons but is designed to staud forces of 1200 tons. Its many exclusive design features are a result of Alliance's knowledge of mill problems and requirements. They design the world's biggest cranes, manipulators and special machinery. Their experience assures you the best in modern design. A letter, wire or phone call will put your problems into the hands of The World's Largest Builders of the World's Largest Cranes.

THE ALLIANCE MACHINE COMPANY

EXCLUSIVE with ALLIANCE

The Alliance Impact Stool Loosener makes your stripper crane more useful, more efficient and saves wear and tear on the crane and ingot buggies. The Impact Stool Loosener can be installed on most stripper cranes now in your service.

Alliance

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

• MAIN OFFICE • ALLIANCE, OHIO

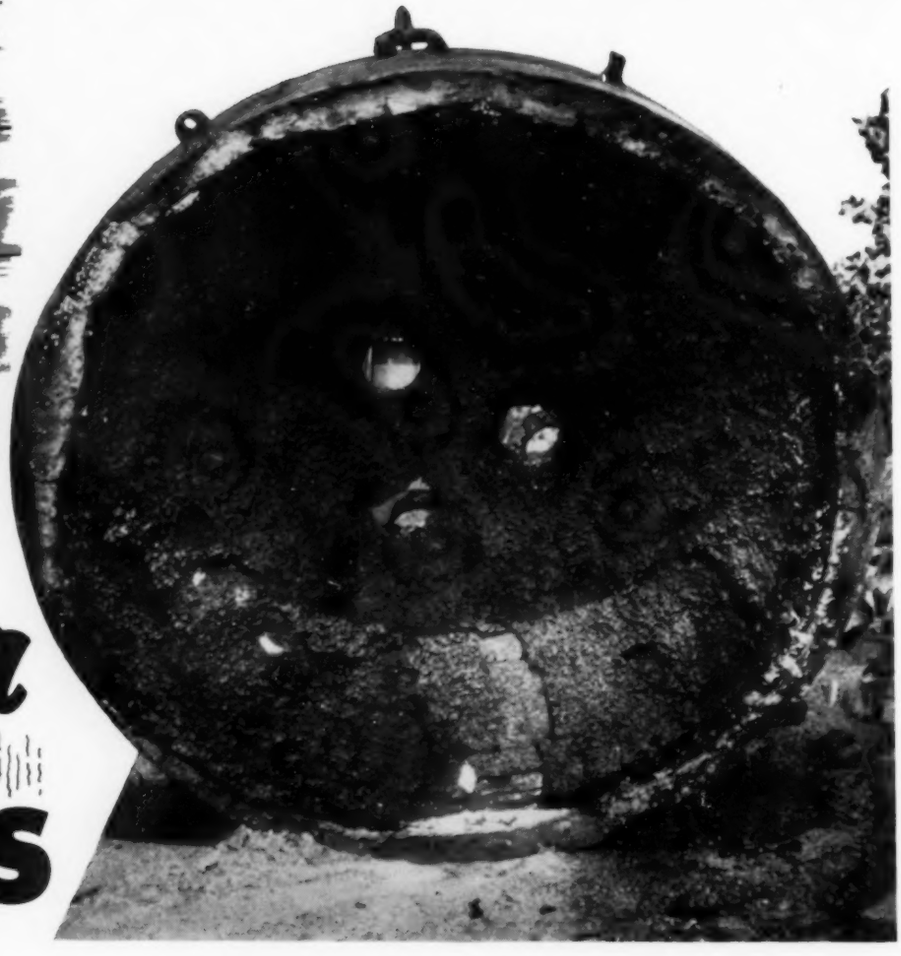
ROOF LIFE DATA FOR 1000-LB. DIRECT ARC ELECTRIC FURNACE

plastic firebrick roofs
33 heat average

mullite plastic
116 heat average

TAYCOR Ramming Mix
first roof—241 heats
second roof—254 heats

Roof of TAYCOR Ramming Mix for 1000-lb. direct arc furnace after 254th heat.



Extra HEATS

gained by TAYCOR roofs for direct arc furnace

The Fahralloy Company, Harvey, Illinois, operates a 1000-lb. basic direct arc furnace, melting 30-35 heats of heat and corrosion resistance alloys per week. Usual charge is 1500 lbs.

After changing from acid to basic furnace practice, tests were run with the following results: Silica roofs averaged 13 heats. Super-duty plastic firebrick roofs averaged 33 heats. Rammed roofs of competitive mullite plastic averaged 116 heats.

The first TAYCOR rammed roof set a record of 241 heats. The next TAYCOR roof jumped the record to 254 heats, some of them up to 3600-lb. triple sized ones.

Among the TAYCOR advantages reported by Fahralloy are:

Longer roof life
No dripping
Longer sidewall life
Less slag

Try TAYCOR Ramming Mix for your next direct arc roof. Let the Taylor field engineer in your area give you full details.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

TAYLOR ZIRCON · TAYLOR SILLIMANITE

The **CHAS. TAYLOR SONS Co.**
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REG. U. S. PAT. OFF.
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

Puts squeeze on steel tubes...

TIMKEN® bearings put squeeze on costs

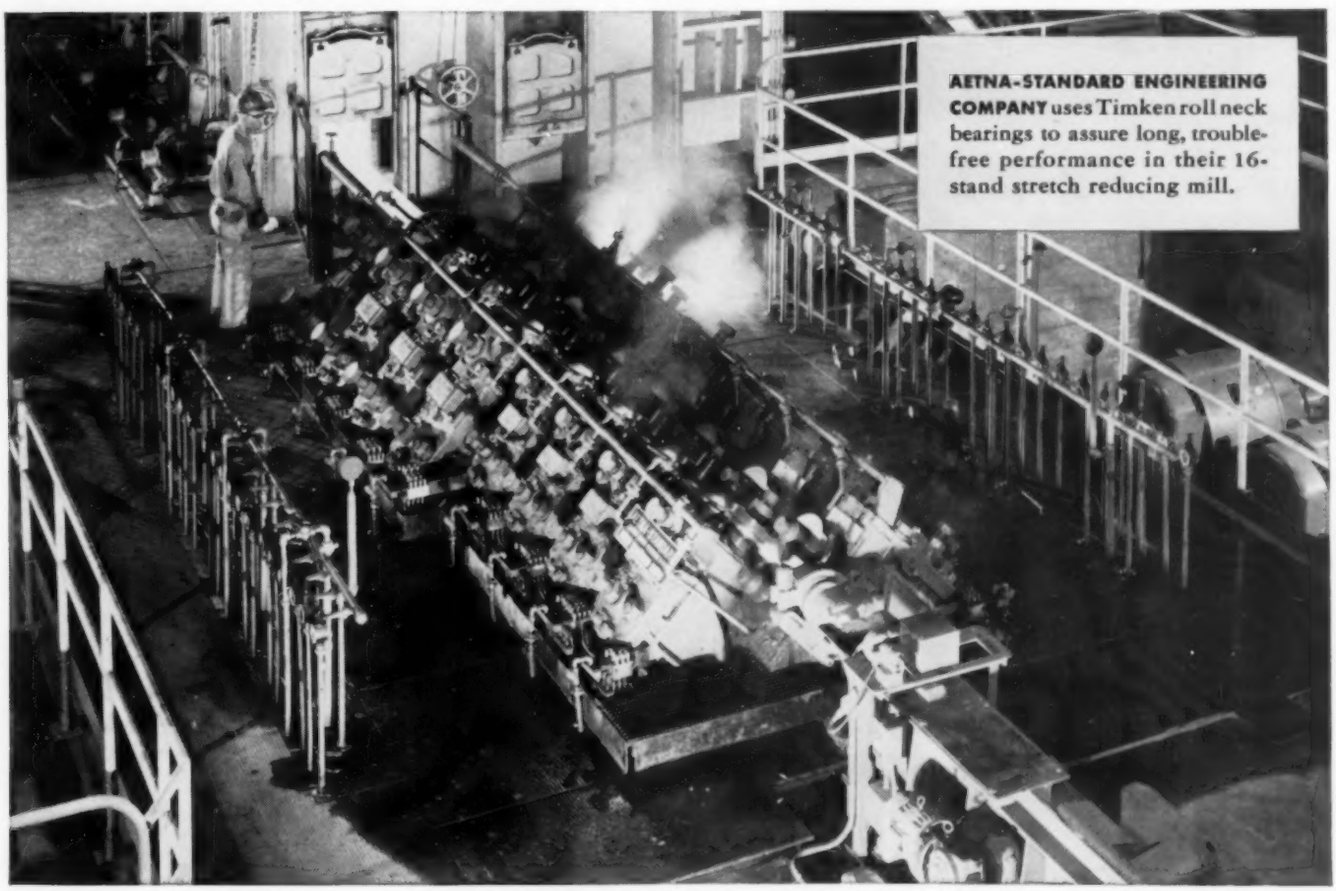
TO keep production high, downtime low, Aetna-Standard Engineering Company mounted the roll necks of their 16-stand tube stretch reducing mill on Timken® tapered roller bearings. One of the few of its kind in the world, this new mill, in operation at Jones & Laughlin Steel Corporation — Aliquippa Works, uses varying-speed rolls to reduce diameter and wall thickness of steel tubes.

Timken roll neck bearings give longer, trouble-free service because their balanced proportion design provides maximum bearing capacity in available space. And balanced proportion design means greater mill rigidity. With Timken bearings roll neck strength is increased 50% to 60% and load ratings up to 40%. Their tapered design enables them to take radial and thrust loads or any combination. No expensive thrust devices are needed.

Mills with Timken bearings can be started under full load. No steel is wasted because of disturbed gauge settings. Higher rolling speeds are possible because Timken bearings are designed for economical grease lubrication. Rolls can also be changed faster.

Why not get all these advantages in the machines you buy or build? Or in existing machines? Timken balanced proportion roll neck bearings can reduce downtime, cut costs for you, too. For full information, consult our roll neck specialists. Write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

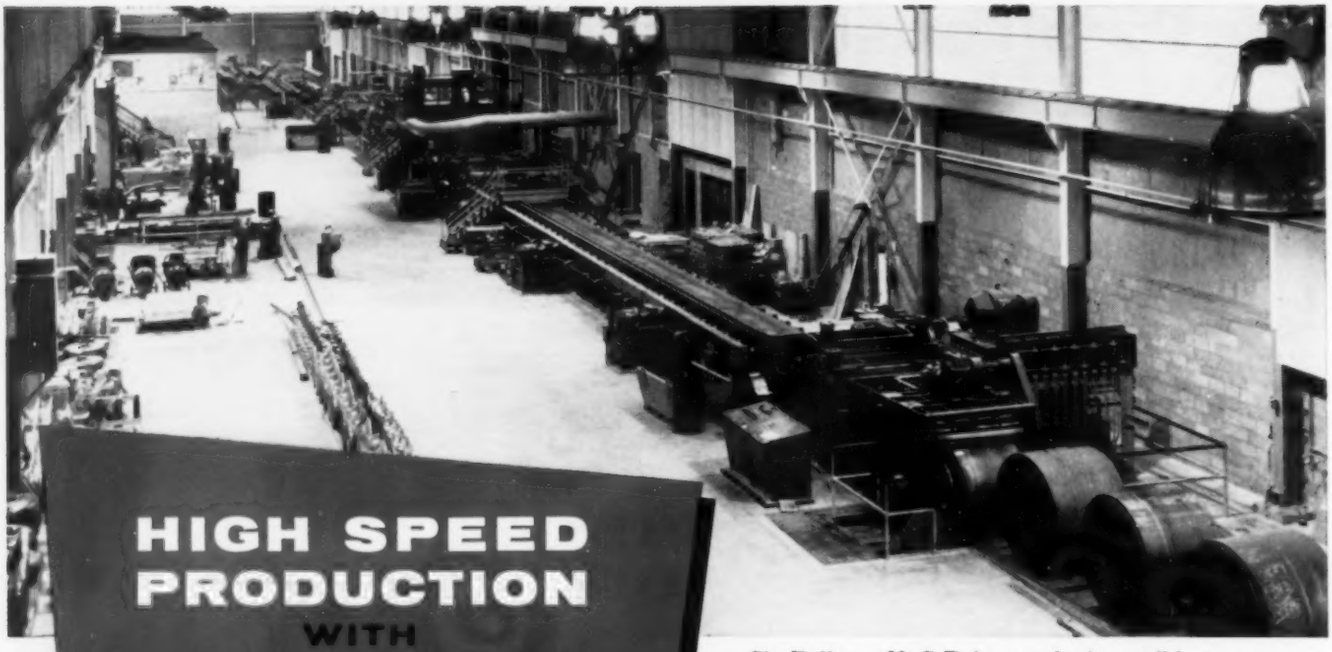
This symbol on a product means its bearings are the best.



AETNA-STANDARD ENGINEERING COMPANY uses Timken roll neck bearings to assure long, trouble-free performance in their 16-stand stretch reducing mill.

TIMKEN TAPERED ROLLER BEARINGS ROLL THE LOAD

TRADE-MARK REG. U. S. PAT. OFF.



HIGH SPEED PRODUCTION WITH RELIANCE V★S DRIVES

Six Reliance V★S Drives make it possible to operate this complete line as if it were a single machine.

Carloads of pipe are pouring out of the new Edmonton, Alberta plant of Alberta Phoenix Tube & Pipe, Ltd. This $6.5 million installation is producing pipe at unprecedented rates.

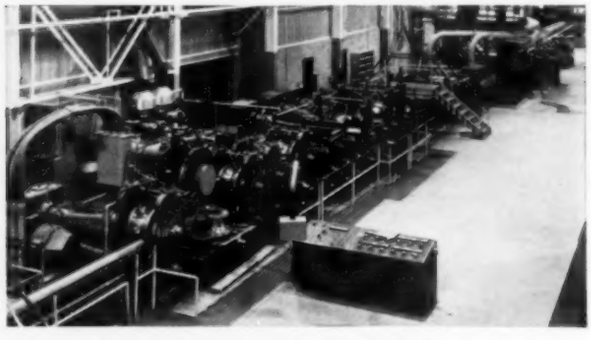
Volume pipe production requires something special in a drive system—one that furnishes precise speed control and instantaneous motor response. A wide stepless range of speeds is provided to handle various pipe diameters and lengths, and all sections of the line operate at the same relative speed.

A team of Reliance Application Engineers, working with the machinery builder, built this specialized drive. This team knows the processes of the steel industry and how to handle the problems involved. Engineering knowledge, backed by the quality of Reliance products, supplied this accurate, simple-to-operate, economical drive.

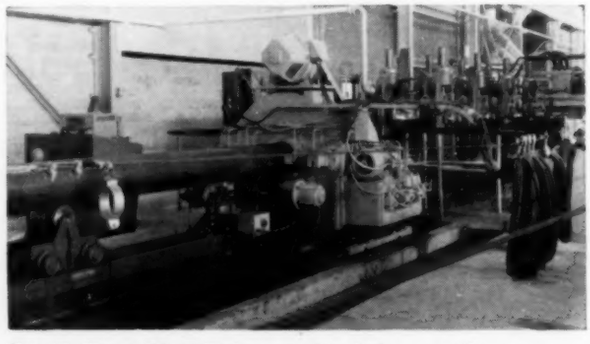
The Reliance Application Engineering Department builds drives for every industry. A team of engineers who are experts on your industry's operation, stand ready to engineer and build the drive for your particular needs.

If you would like more information on this installation, write for Bulletin L-2505.

L-1641



The welding section operator controls the speed of the entire line from this Reliance Pendent Station.



The Reliance V★S Drive on this flying cutoff automatically measures the pipe and controls the movement and speed of the carriage.

RELIANCE ELECTRIC AND ENGINEERING CO.

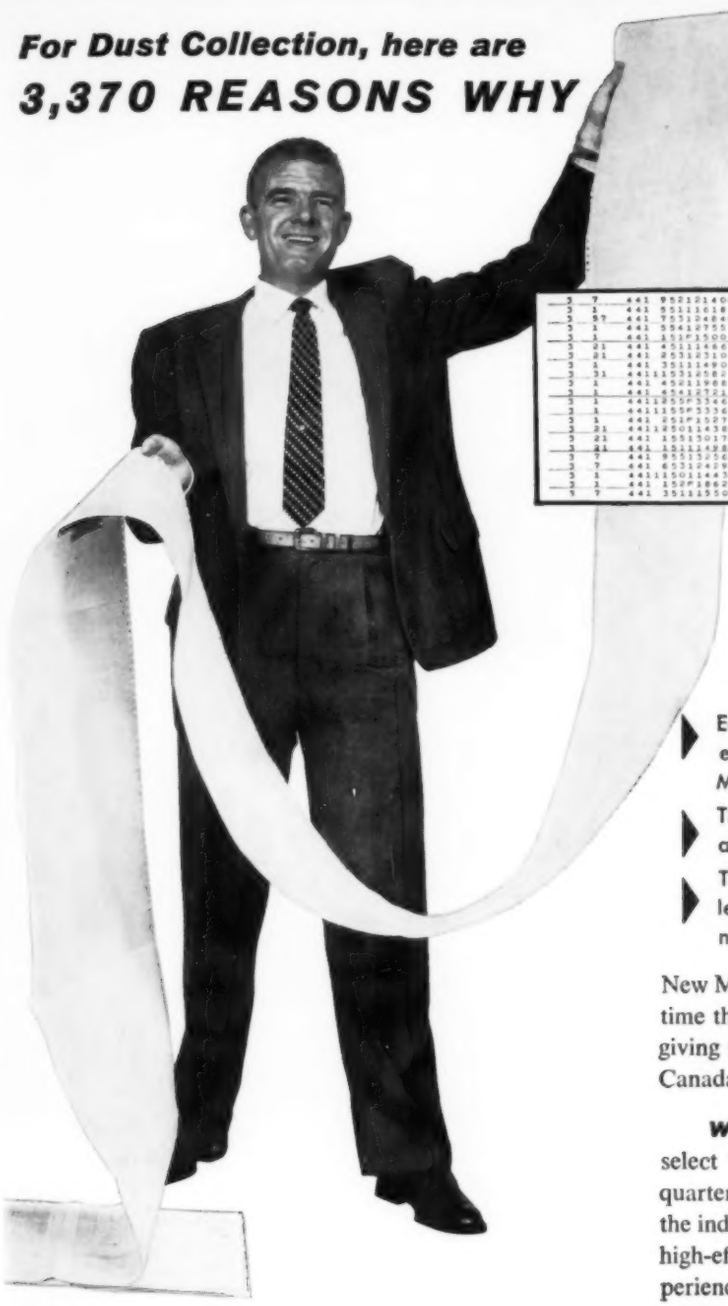
DEPT. 116A, CLEVELAND 17, OHIO • CANDIAN DIVISION: WELLAND, ONTARIO

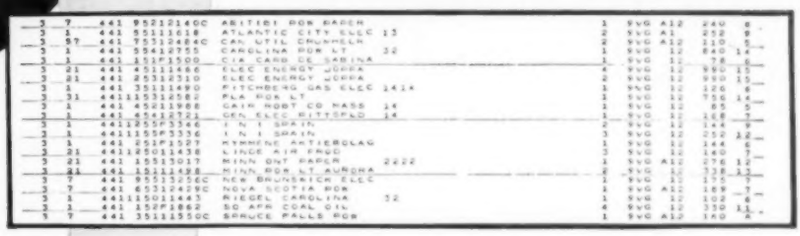
Sales Offices and Distributors in Principal Cities

For Dust Collection, here are

3,370 REASONS WHY

You're Years Ahead with MULTICLONE





The tabulation sheet shown here is over 40 feet long, filled top to bottom with single-spaced typewriter listings as in the enlarged section above...

- Each typewritten line tabulates an installation of Multiclone equipment—an installation of from one to nine separate Multiclone units!
- These installations have been made in all parts of the world and in plants operating under widely-varying conditions.
- They include installations on virtually every type of dust collection problem—cement, non-metallic minerals, ferrous and non-ferrous metals, chemicals and many others.

New Multiclone installations are being made every day, but at the time this tabulation was made there were 3,370 Multiclone units giving superior service to industry throughout the United States, Canada and other countries.

What does this mean to you? Simply this—when you select "Multiclone" you are getting equipment that has over a quarter-century of experience behind it...equipment backed by the industry's greatest fund of "know-how" in modern small tube, high-efficiency cyclonic collection. Although this unequalled experience is a part of every Multiclone installation, you pay nothing extra for this vital advantage!

Send For Descriptive Literature on Multiclone Equipment!

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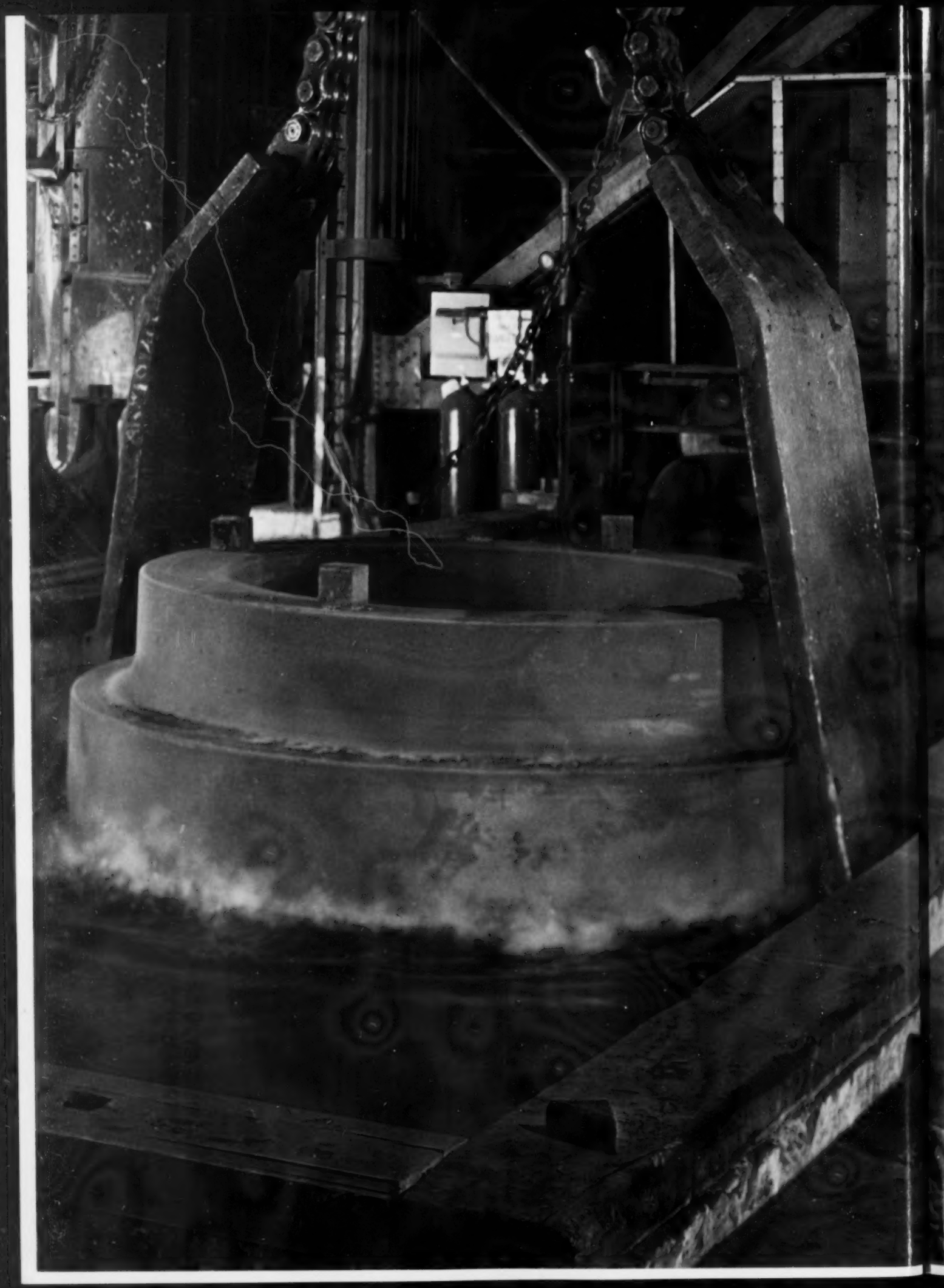
Representatives in all principal cities



"Here's the trick: quench this forging so it won't warp,"

says **A. H. Sauer,** *USS General Foreman—Heat Treating*

In the whole complex business of steelmaking, heat treating of the finished part is one of the steps that requires *exceptional* care. The problems are multiplied many times over when you have a 74-ton forging like the one in the picture—a flange forging for a nuclear power reactor.

In forgings, heating and quenching operations must be carefully controlled to insure proper structure in the steel. Using the acquired skill that only time and experience could give him, Al Sauer, a 29-year veteran in our Homestead Forgings Division, supervised the careful heating of this forging for five days. After this came the rapid quench; the entire piece was immersed in water. Then, Al had the crane lift the piece until only the lower flange was submerged. With careful timing, the piece was then submerged again for an over-all quench.

If the entire piece had been immersed for the complete quench, the thinner top section would have cooled too fast, and the resultant contraction may have warped the entire forging. But in this case, through Al's experience and supervision, the warpage was kept within practical limits.

We're not suggesting that this is the forging problem of the century. But it does show the kind of demanding assignments that are *routine* in the shop that makes USS Quality Forgings.

If you'd like a free copy of our 32-page booklet, "USS Quality Forgings," just write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS QUALITY FORGINGS

heavy machinery parts . . . carbon, alloy, stainless

forged steel rolls and back-up roll sleeves

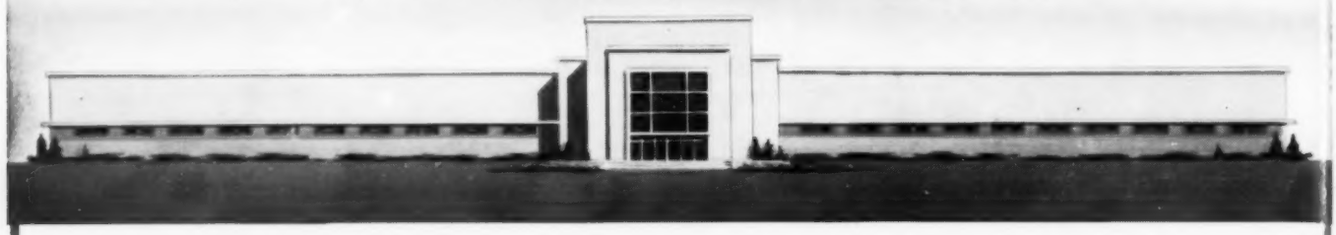
electrical and water wheel shafts

specialty forgings of all types

USS

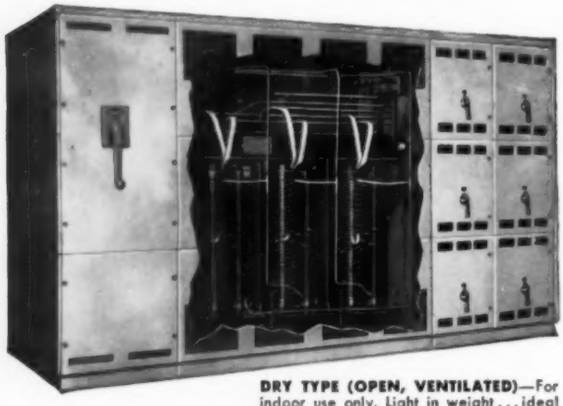
UNITED STATES STEEL

Can your in-plant distribution system meet tomorrow's needs?



WAGNER UNIT SUBSTATION TRANSFORMERS

will assure continuous dependable power for years to come!



DRY TYPE (OPEN, VENTILATED)—For indoor use only. Light in weight... ideal for multi-storied buildings... no fireproof vaults necessary.

Nothing is more important to your plant than an uninterrupted flow of power. You can't afford to be handicapped by a system that is unable to meet expanding demands.

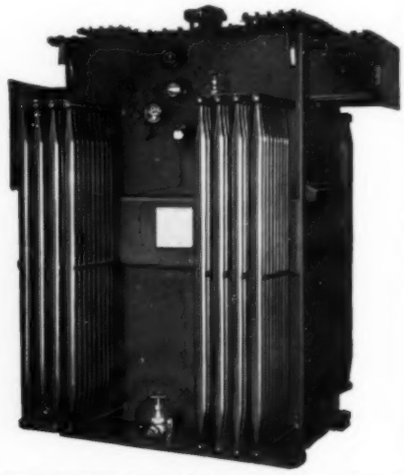
It will pay you to check over your distribution system—find out how adequate your transformers are for present and *future* load requirements.

And it will pay you to specify Wagner PREDESIGNED Transformers for your load-centers. You will save time—save job engineering costs—and get liberally designed transformers with the switchgear of your choice. Wagner PREDESIGNED Transformers are engineered to meet heavy industrial demands. They are built in standard ratings which are coordinated with the specifications of unit substation builders.

Bulletins TU-205 and TU-214 give full information on Wagner Unit Substation Transformers for industrial power needs. Write for your file copies today.

CLOSE-COUPLED. These transformers fit flush against switchgear enclosures, eliminating throats and saving space... available in ratings from 500 through 2000 kva.

NITROGEN-FILLED. These Class H. Silicone Insulated Transformers offer many advantages in maintenance and safety. Suitable for indoor or outdoor use... completely fireproof. In ratings up to 2000 kva.



OIL AND NOFLAMOL-FILLED. Oil-filled transformers are generally used outdoors. Noflamol type is filled with a noninflammable liquid making it especially suitable for locations where explosive liquids and gases are present.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

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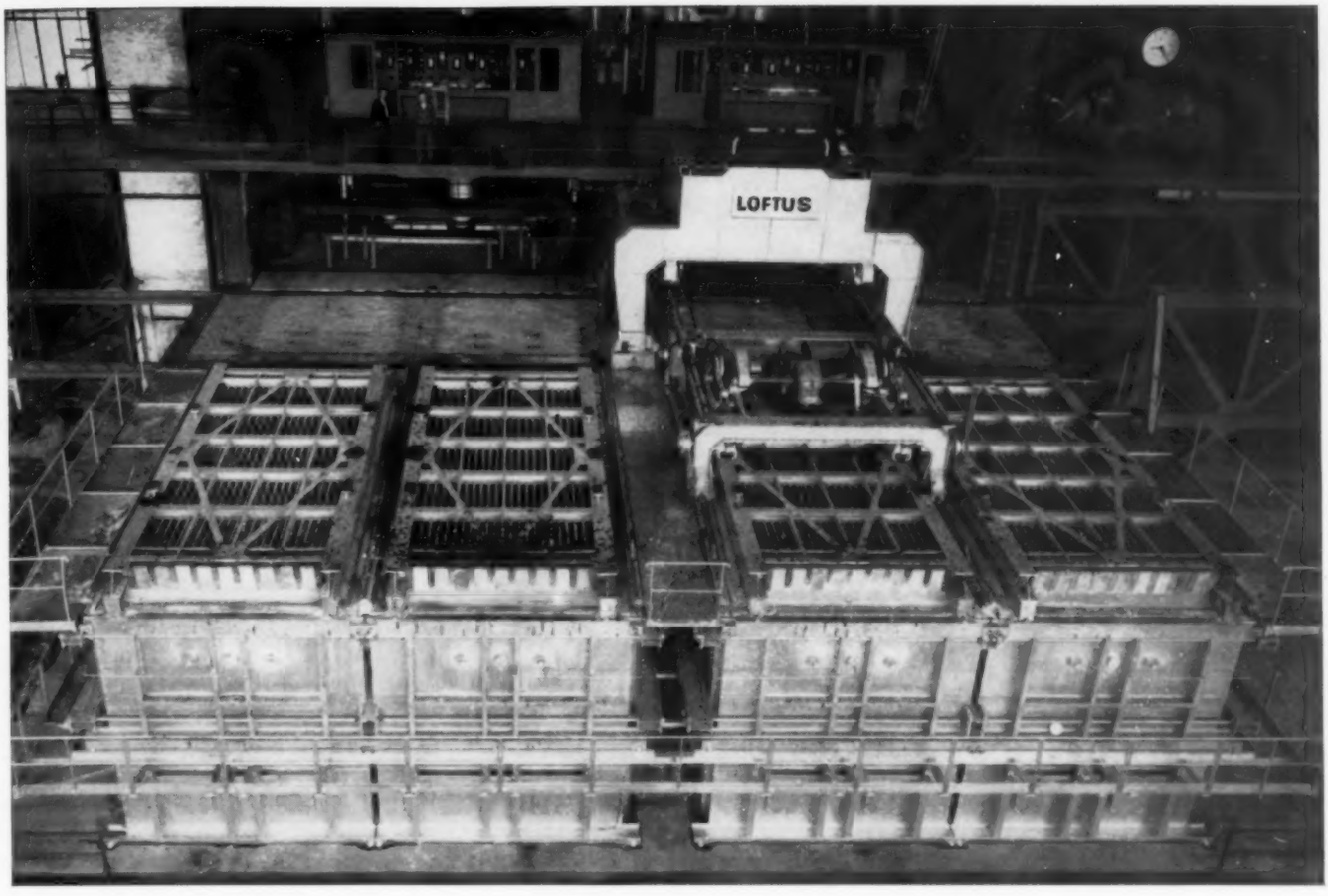
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC



LOFTUS PIT FURNACES

Insure top performance for each investment dollar, with the following distinct advantages:

- **Less investment with multi-purpose cover crane**
- **More production with heat acceleration**
- **More economy with integrated recuperation**
- **More uniform soak with flame tempering**
- **More setting capacity with top firing**
- **More flexibility with any fuel combination**
- **Less maintenance with flush carriage rails**

We solicit an opportunity to discuss your requirements—without obligation.

From first heat to heat treat, look to . . . **LOFTUS**
Engineering Corporation
1 Gateway Center, Pittsburgh, Pa.
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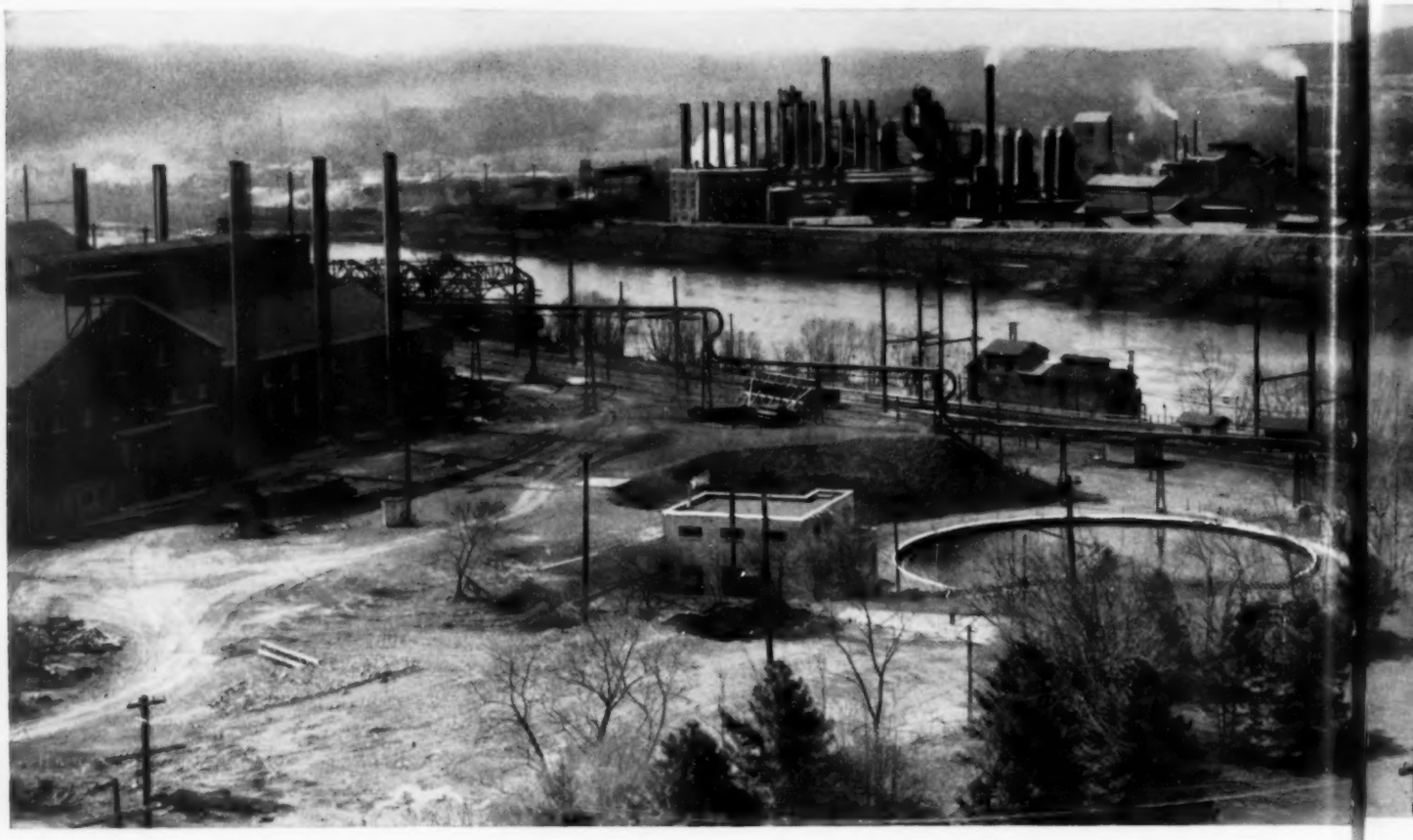
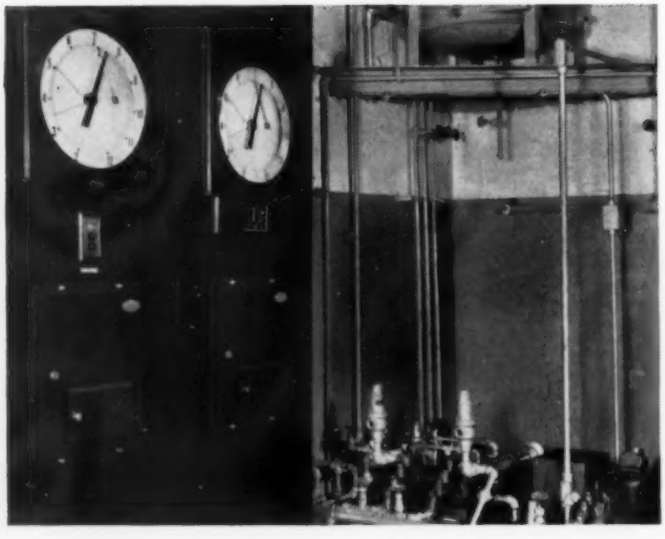
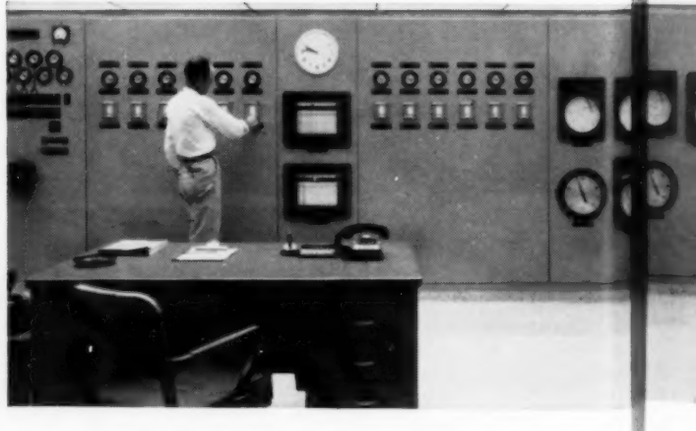


Reduce your water and

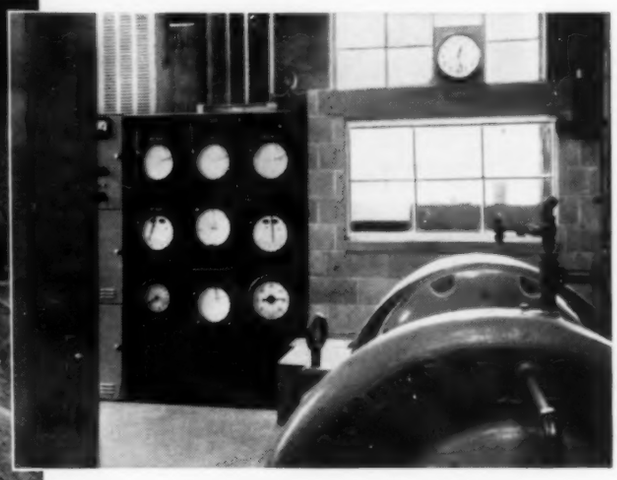


IN THE TEXTILE INDUSTRY—Alum usage was cut 95% when Honeywell controls were installed to clarify turbid river water at the textile mill of James Lees and Sons Company, Bridgeport, Pa. Use of other chemicals also decreased after installation of continuous alkalinity measurement and controlled chemical feeding systems engineered and built by Honeywell. 10



IN MUNICIPALITIES—Centralized instrumentation, incorporating a Honeywell *Filtermatic* control system, increases efficiency and cuts the supervisory workload at the O. N. Stevens Water Filtration Plant, Corpus Christi, Texas. At his instrument panel, a single operator can see everything he needs to know about the functioning of 12 filters that treat 48 million gallons of water daily.

IN THE STEEL INDUSTRY—At the Alan Wood Steel Company plant, Conshohocken, Pa., Honeywell controls condition both incoming river water and waste, treat a total of 20 million gallons of water daily. By providing a constant supply of uniform water, Honeywell controls effect savings throughout the plant. Controlled waste disposal helps build a good-neighbor reputation for the company.



waste treatment costs...

with Honeywell Instrumentation

In water treating operations, Honeywell instrumentation provides—automatically—a constant supply of uniform water. Treatment-chemical requirements are drastically reduced. Supervisory workloads are lightened. Process equipment is protected from corrosion by contaminated water. Improvement of overall production operations is a frequent end result.

In waste treating operations, Honeywell controls offer the economical answer to meeting government stream pollution regulations and maintaining good community relations. In some instances, dependable Honeywell controls pay for themselves by permitting profitable recovery of raw materials from waste.

Honeywell, the world's largest manufacturer of automatic controls, is ready to make *customized instrumentation* a rewarding reality in your own plant . . . for water and waste treatment, or for *any* phase of your production operation.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

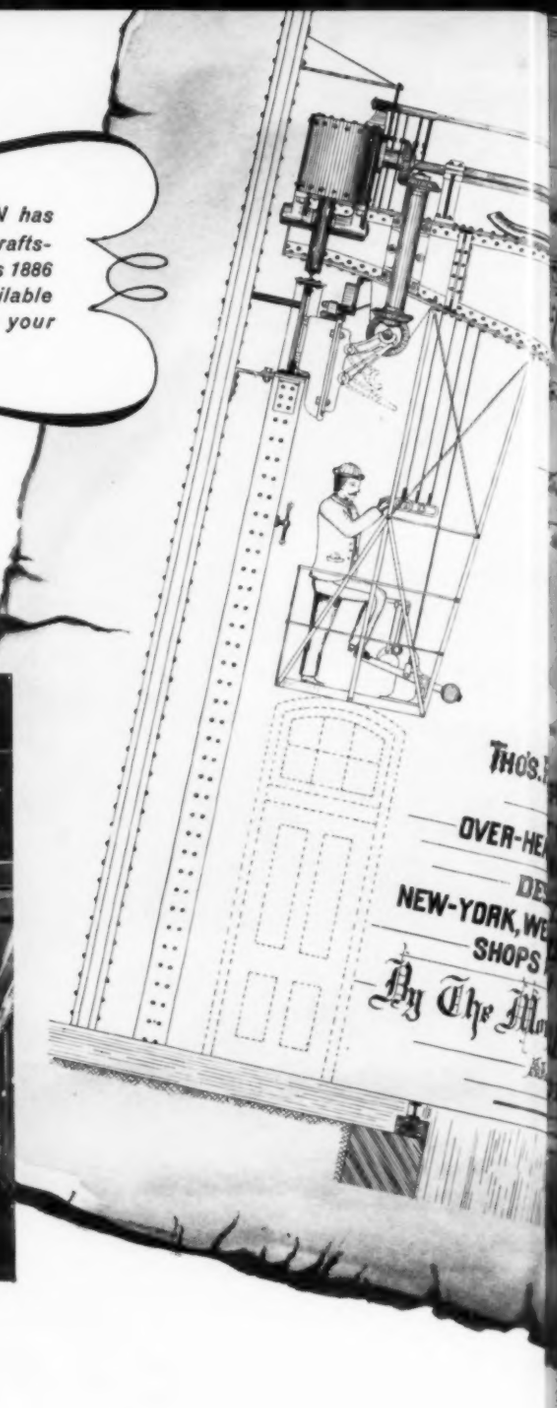
H HONEYWELL

MINNEAPOLIS **Honeywell**

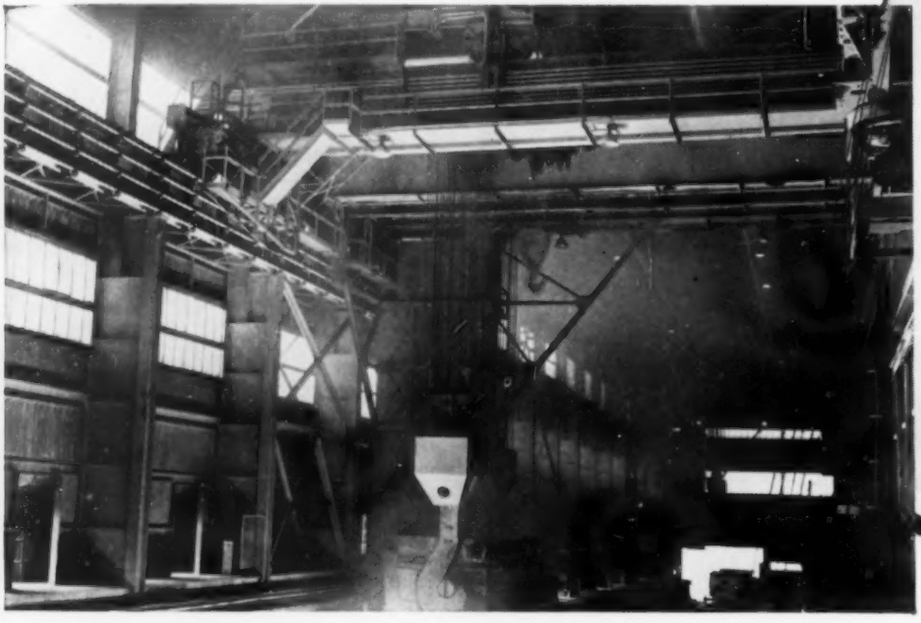
BROWN INSTRUMENTS

First in Controls

Since 1868, *the name MORGAN has stood for advanced design and trusted craftsmanship. A 14" x 20" reproduction of this 1886 patent drawing of a 35-ton crane is available for framing. Kindly send request on your company letterhead.*



CONTRAST *the controls of 68 years ago—pull ropes that engaged clutches on square shafts and a foot brake—with those of the modern Morgan crane. Today the operator rides in air-conditioned comfort. His controls automatically suit themselves to handling conditions, assuring maximum speed, safety and accuracy.*



Time Counts

. . . wherever metal is made,

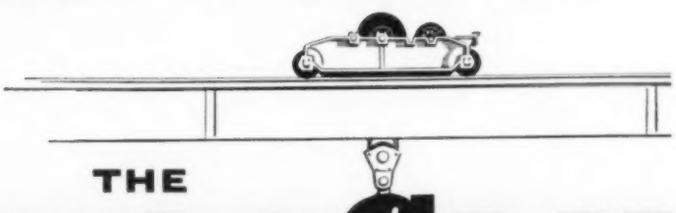
Speed production, cut costs, with Morgan Cranes and Mill Equipment

Advanced design and trusted craftsmanship are 89-year old Morgan traditions... important characteristics in the cranes, mills, chargers, and shears which must do the big, tough jobs in today's steel mills.

Since 1868, Morgan equipment has been used at the vital spots in maintaining continuous, lower cost production. Years of close contact with metal-producing problems and farsighted research have resulted in a steady flow of mill equipment improvements . . . greater speeds and efficiency, greater capacities, lower operating and maintenance costs wherever you see the nameplate, "Morgan—Alliance, Ohio—U.S.A."

Let our representative show *you* how time counts in increasing production and profits . . . with Morgan equipment.

moved or worked



THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*

Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws and auxiliary equipment.

SCHLOEMANN

8,000 TON FORGING PRESS

Main Characteristics

Pressure stages: 2,700/5,400/8,000 tons
Height: 49 ft, 33 ft above floor level
Stroke: 71 in • Pressing speed: 3 in/sec

High strength aluminum forgings up to 500 square inches in area are now being produced by this giant hydraulic forging press. Larger products of conventional designs may be forged; and forgings featuring thin ribs, thin webs at low draft angles can be made which require only little or no machining.

Control of the press is executed from the small mobile desk, at right. The four tubular struts attached to each top corner of the press serve as "earthquake protectors."

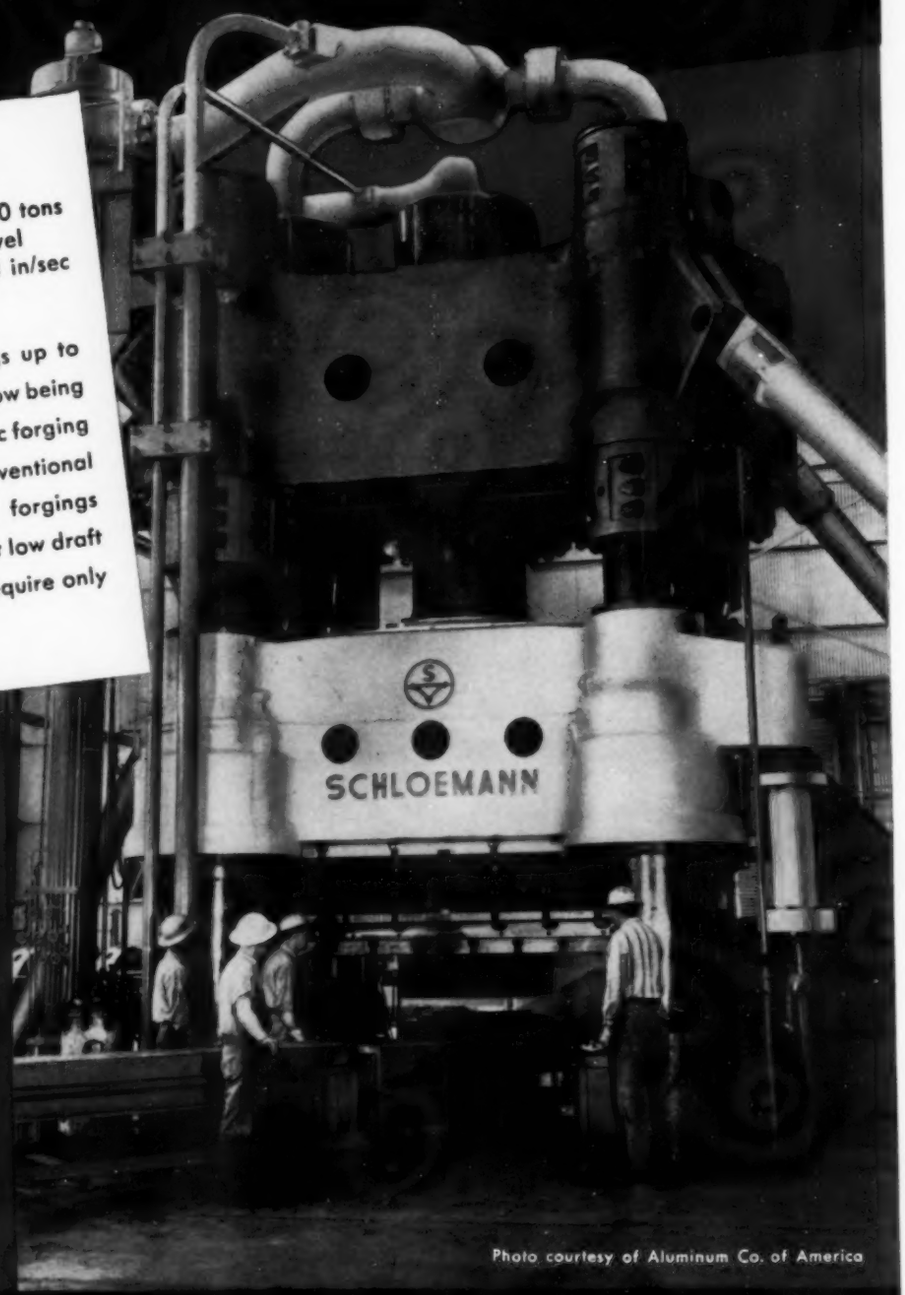


Photo courtesy of Aluminum Co. of America

FELLER ENGINEERING COMPANY
1159 Empire Building, Pittsburgh 22, Pa.
Exclusive U.S. Agent

ROLLING MILLS FOR FERROUS AND NON-FERROUS METALS • COUNTERBLOW HAMMERS • HYDRAULIC PRESSES

LET EF FURNACES help you BEAT last year's figures

Designed to meet your specific requirements, and incorporating the most advanced heating practices, EF furnaces assure high heating efficiency, accurate automatically controlled cycles, minimum maintenance, continuous trouble-free operation and high hourly outputs. The uniformity of heat treatment reduces the cost of subsequent forming, fabricating and finishing operations, further cutting production costs.

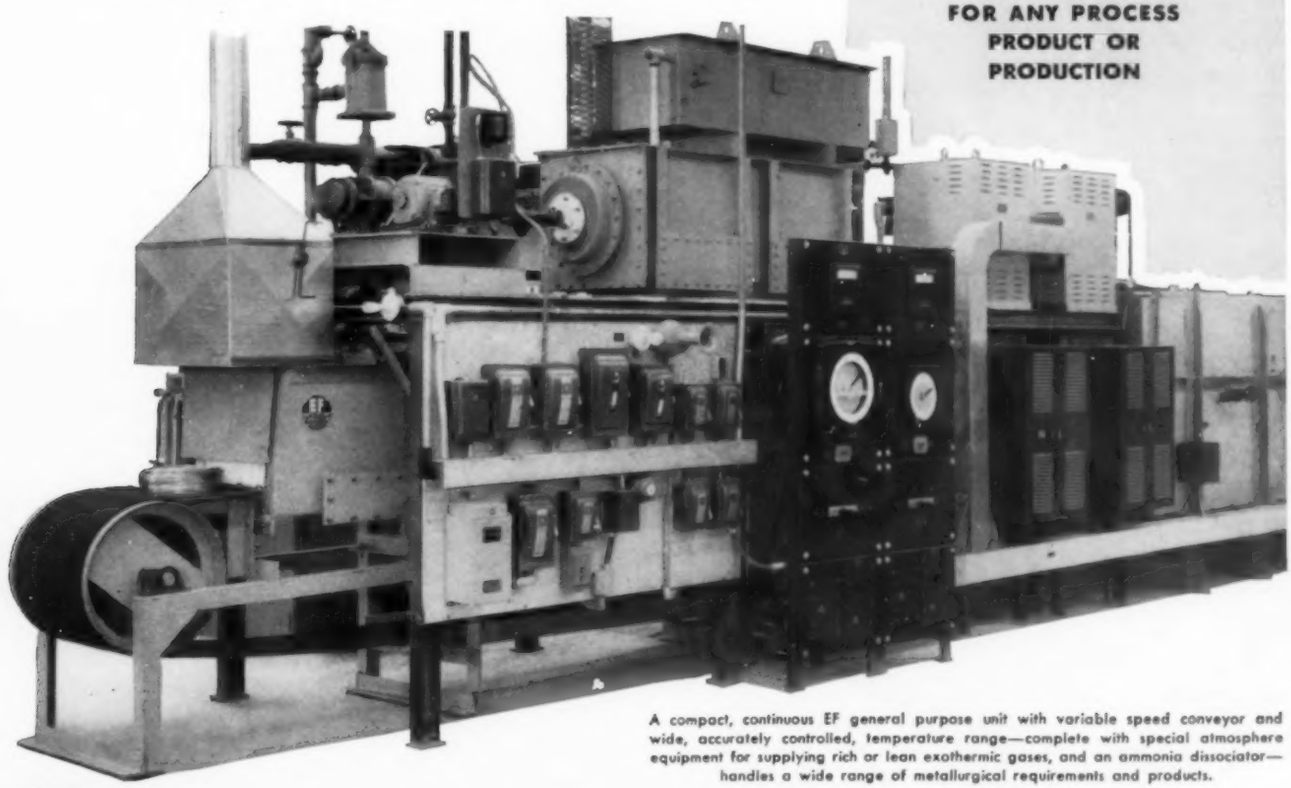
Built in continuous and batch types including roller hearth, roller rail, chain belt, wire belt, slot and tube conveyor, reciprocating, rotary, car, bell, pit and other designs for any ferrous or non-ferrous heating or heat treating process. Furnished complete with special atmosphere producers and any material handling equipment required. For utmost satisfaction — and economy — submit your furnace problems to experienced EF engineers, — ***You'll find it pays.***

EF

GAS-FIRED OIL-FIRED AND ELECTRIC FURNACES *for*

- AGING
- ANNEALING
- BRAZING
- BILLET HEATING
- CARBON RESTORATION
- CARBURIZING
- CARBONITRIDING
- DRAWING
- GALVANIZING AND ALUMINIZING STRIP
- HARDENING
- HOMOGENIZING
- MALLEABLIZING
- NORMALIZING
- NITRIDING
- SINTERING
- SOLUTION TREATING
- SPECIAL ATMOSPHERE TREATMENTS
- STRESS RELIEVING

A SIZE AND TYPE FOR ANY PROCESS PRODUCT OR PRODUCTION



A compact, continuous EF general purpose unit with variable speed conveyor and wide, accurately controlled, temperature range—complete with special atmosphere equipment for supplying rich or lean exothermic gases, and an ammonia dissociator—handles a wide range of metallurgical requirements and products.

THE ELECTRIC FURNACE CO.

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Salem - Ohio

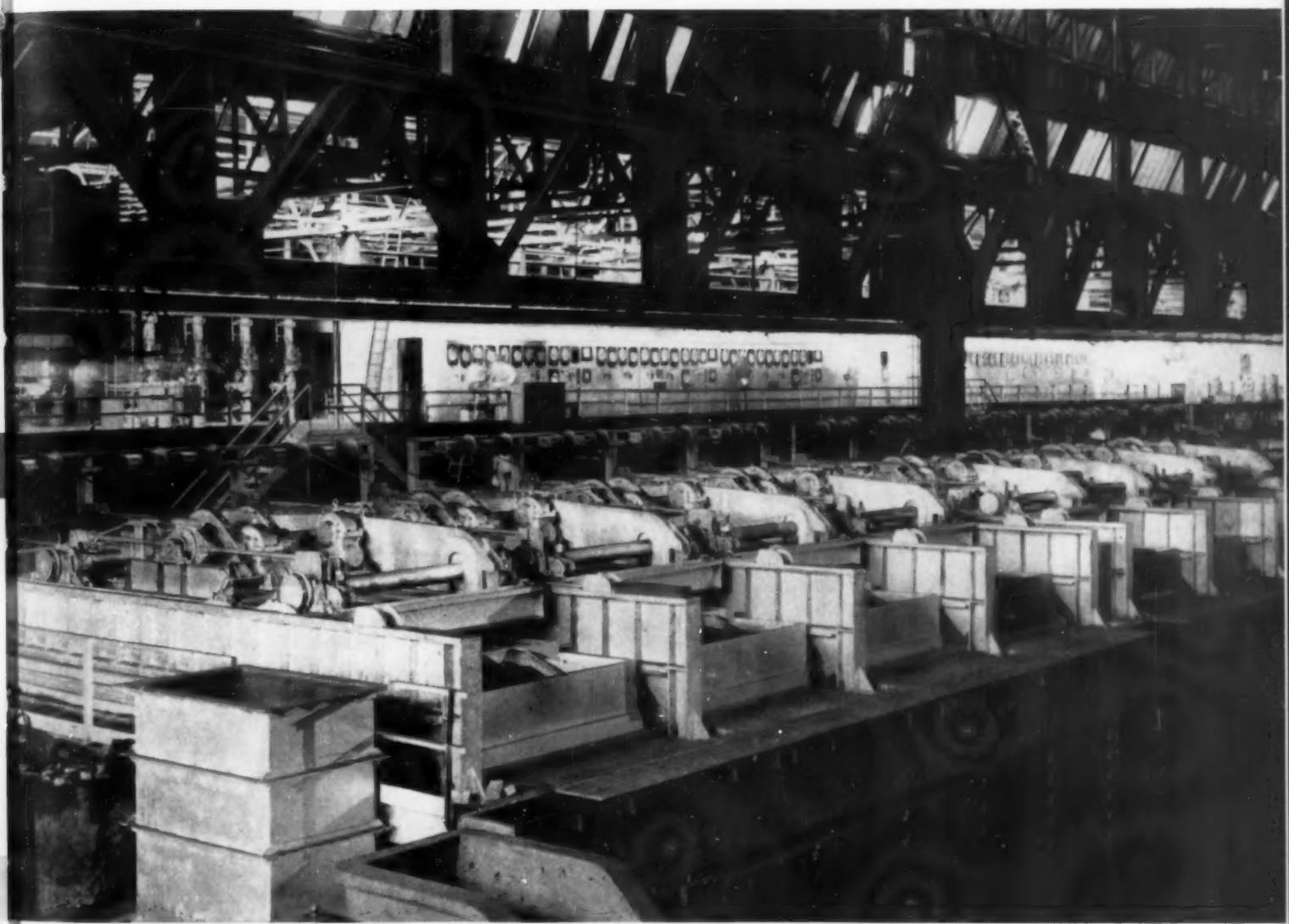
Canadian Associates • CANEFCO, LIMITED • Toronto 1, Canada

The pit
nobody
liked...
except
our
customers

This is of course our one-way fired soaking pit . . . fired from the top.

The location of the burner is only one of the features responsible
for its enthusiastic acceptance. Most important however
are the 30 years of experience and refinements
which we have built into the pit since we first introduced it.

That is why, today, it is the pit
everybody respects . . . especially our customers.



STEEL MILL, HEAT TREAT, GLASS DIVISIONS

SURFACE COMBUSTION CORPORATION

2404 DORR ST., TOLEDO 1, OHIO

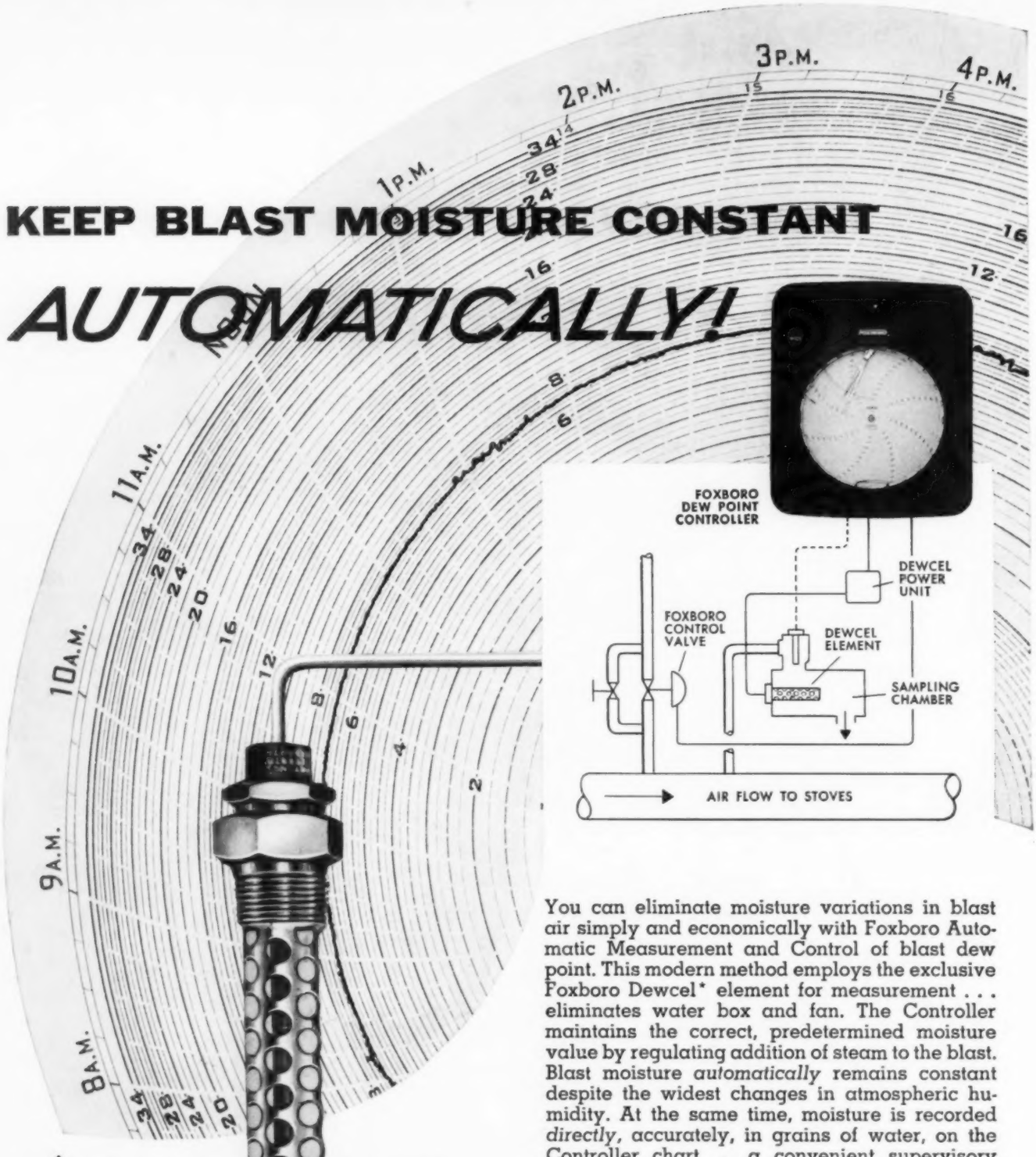
wherever heat is used in industry

Associated Companies: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein & Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld

Surface®

KEEP BLAST MOISTURE CONSTANT

AUTOMATICALLY!



▲ Section of Foxboro Dew Point Controller Chart showing typical moisture control record from actual installation. Control action automatically balances changes in atmospheric humidity.

◀ The Foxboro Dewcel element is a highly accurate, rugged, moisture-sensing element designed for industrial use. It requires no water box — practically never needs attention.

You can eliminate moisture variations in blast air simply and economically with Foxboro Automatic Measurement and Control of blast dew point. This modern method employs the exclusive Foxboro Dewcel* element for measurement . . . eliminates water box and fan. The Controller maintains the correct, predetermined moisture value by regulating addition of steam to the blast. Blast moisture *automatically* remains constant despite the widest changes in atmospheric humidity. At the same time, moisture is recorded *directly*, accurately, in grains of water, on the Controller chart . . . a convenient supervisory record.

Foxboro Automatic Measurement and Control of blast dew point has already proved its value in over 50 installations through more stable furnace operation . . . better control of iron quality and uniformity. For full details, write for AED Sheet 330-1 and Bulletin 11-11A. And, if you wish, a Foxboro Engineer will call to make recommendations for *your* furnace. **The Foxboro Company, 586 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO
REG. U. S. PAT OFF

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

AUTOMATIC CONTROL OF BLAST DEW POINT

HERE'S self-alignment

IN A STEEL HOUSING

HOW "MILL BEARINGS" MAINTAIN ALIGNMENT. Spherical inner ring is free to align in any direction. Full load capacity is assured regardless of shaft deflection or misalignment.

"Mill Bearings" are available for shafts up to 11 inches.

SUPER-RUGGED CAST STEEL HOUSING. Cap is anchored solidly by extra large dowels and four heat-treated thru-bolts with serrated steel nuts.

LINK-BELT "Mill Bearings" with steel housings compensate for inaccuracies of welded and concrete support structures

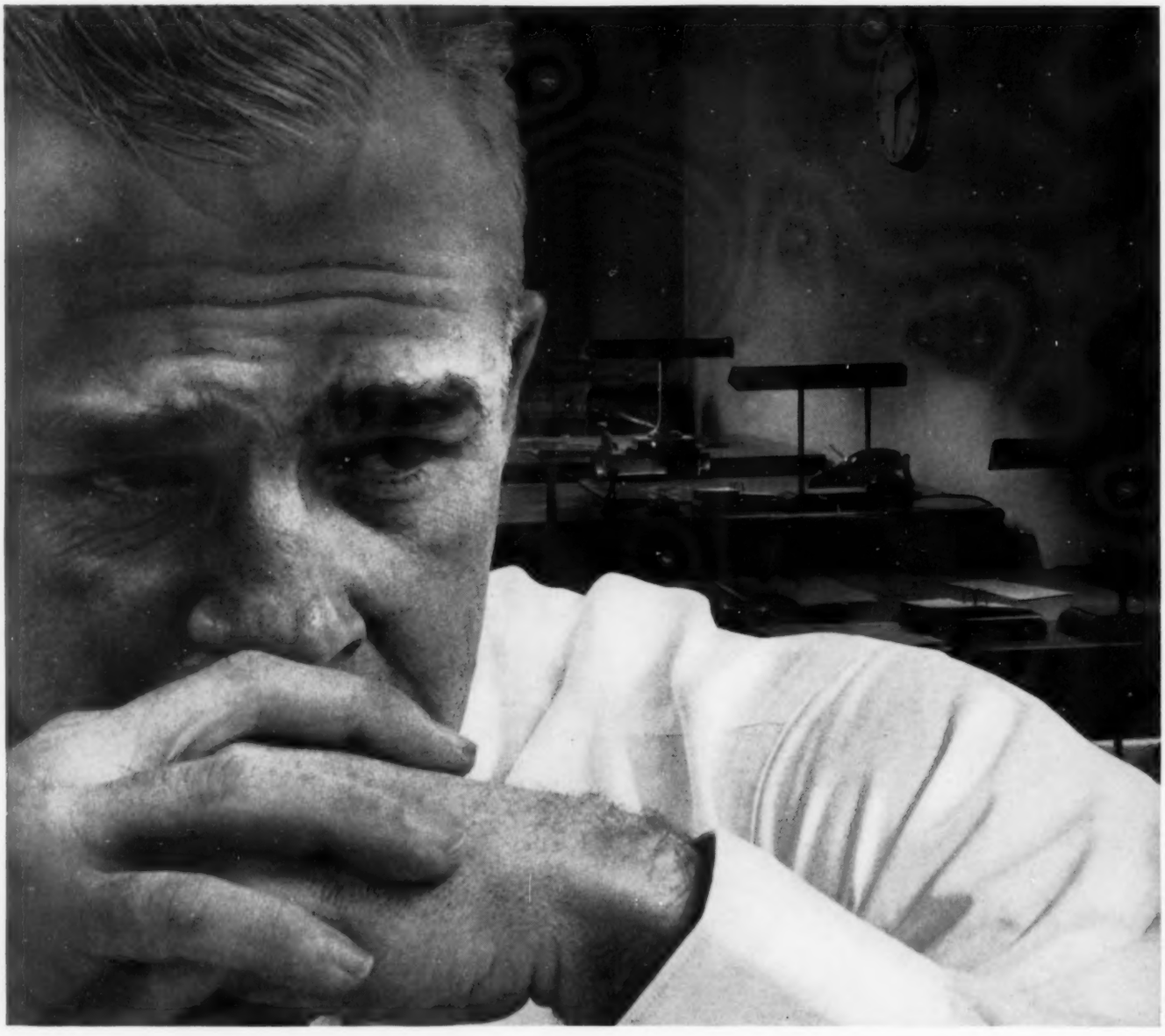
HERE's one bearing really built to take the grind and grime of heavy loads in steel mills, mines, foundries and other extra-severe applications. The self-aligning Link-Belt "Mill Bearings" with cast steel housing adjust for misalignment of shafts and support structures. Furthermore, it eliminates the need for extra heavy shafting to avoid deflections which are ruinous to ordinary bearings.

This bearing is effectively sealed, self-contained, factory-adjusted—needs no shims or alignment rings at installation. Get full facts in Book 2565A . . . or Book 2550, which covers industry's most complete line of self-aligning ball and roller bearing blocks. Ask any of the 40 Link-Belt offices or your authorized stock-carrying distributor. 14.442

LINK-BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.



Do you worry about conduit space for new control circuits
AFTER EVERYONE'S GONE HOME?

If you have a problem in getting additional control circuits in existing conduits — here's one practical way to solve it — specify and use Rockbestos PNR 600 volt control cable. It will help you get a maximum number of control circuits in a minimum amount of space. Here's why:

- Rockbestos PNR lets you pull a 12 conductor control cable in conduit which is now carrying ordinary six or seven conductor cable.
- It's 46% smaller in area — 28% smaller in diameter than conventional control cable.
- With it you save on conduit and fittings, cut installation costs.
- It's flexible from 167° to −67° F.
- It's light, easy to handle, pull through conduits.

Get the complete Rockbestos PNR story — write now for catalog which gives complete specifications and application data.

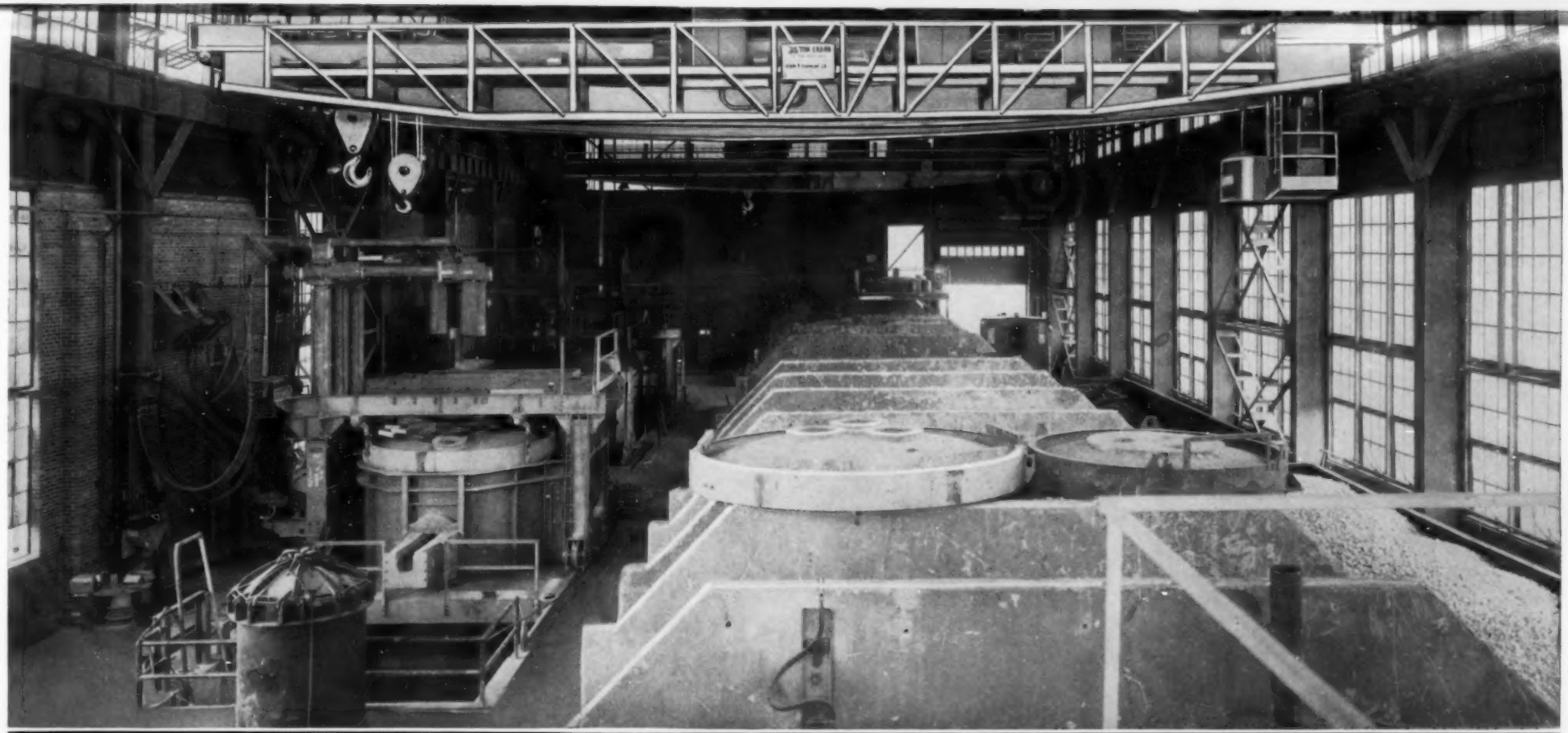
ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN 4, CONNECTICUT | NEW YORK, CLEVELAND, CHICAGO, PITTSBURGH, LOS ANGELES, DETROIT, ST. LOUIS, ATLANTA, DALLAS, OAKLAND, SEATTLE

ROCKBESTOS

PNR
Small Diameter
Control Cable

MORE THAN 10,000,000 FEET IN SERVICE



VICTOR R. BROWNING

Mill Type Cranes

TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

WILLOUGHBY (CLEVELAND), OHIO

DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

longer life...

One of the unseen extra values you get in every

NATIONAL ROLL

If you are getting only *average* tonnage life from your rolls when a different metallurgical composition would give you *longer than average* tonnage life, let our metallurgists study your problem. They may be able to recommend rolls that will result in considerable savings through reduced down time and longer intervals between roll changes.

The fact that so many long-established steel companies are users of National rolls, and have been users for almost 50 years, is proof of their ability to give long tonnage life . . . and now, to produce even better rolls, National has the additional facilities and metallurgical experience of General Steel Castings Corporation, of which National is a division.

So next time you are ordering rolls—iron or steel—call on us for our recommendations.

NATIONAL ROLLS

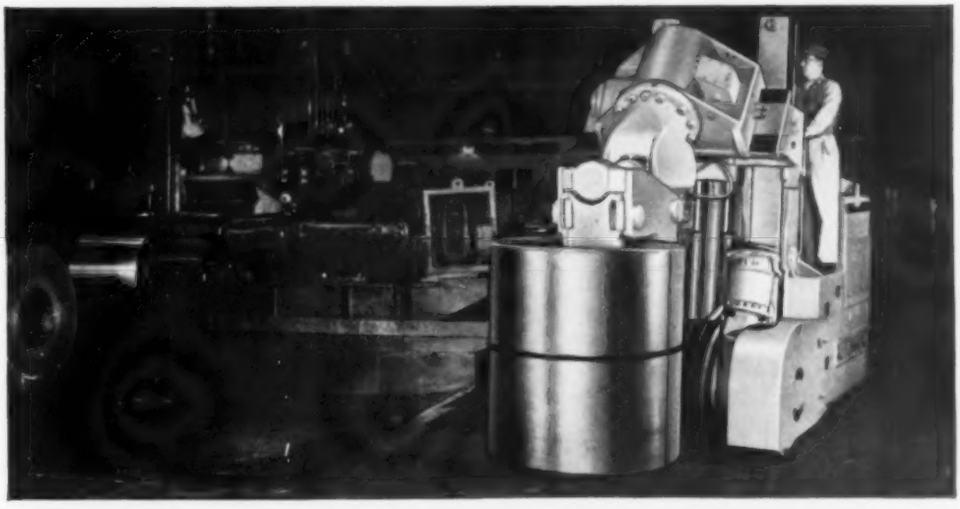
GENERAL STEEL CASTINGS CORPORATION

NATIONAL ROLL & FOUNDRY DIVISION

Avonmore (Westmoreland County) Pennsylvania

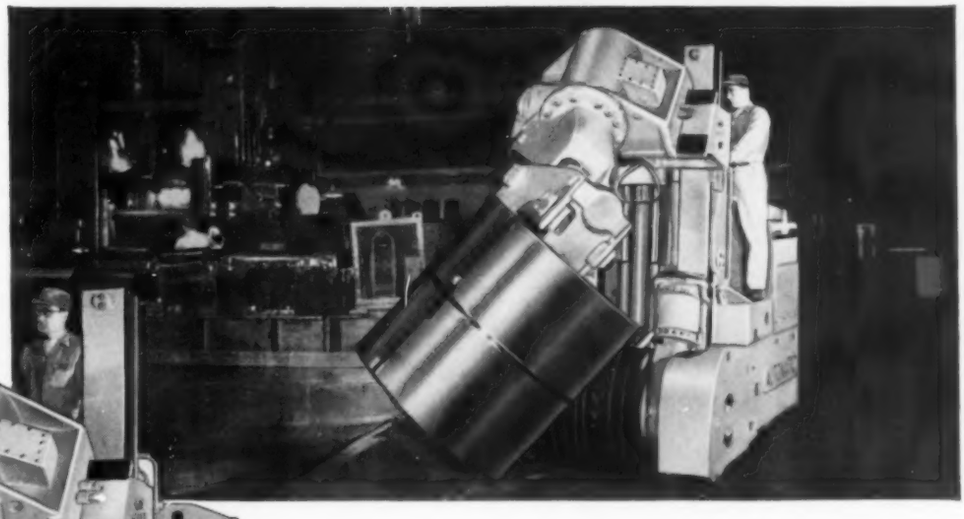
General Steel Castings Corporation: General Offices, Granite City, Ill. • Plants: Granite City, Ill.—Eddystone, Pa.—Avonmore, Pa.

New Automatic Attachment is COIL UP-ENDER AND RAM IN ONE!



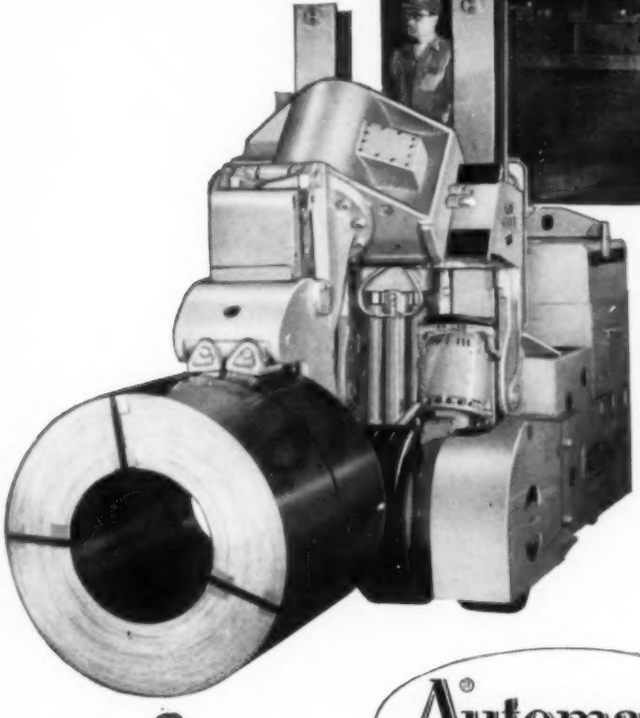
1.

Picks up coil in vertical position and rotates to horizontal or vice versa... handles up to 60,000 lb. coil.



2.

Holds coil securely throughout rotation...prevents telescoping...no distortion, no damage to coil ends.



3.

Transports coil in any position; can be replaced by forks or ram for other uses.

Only Automatic Has It!

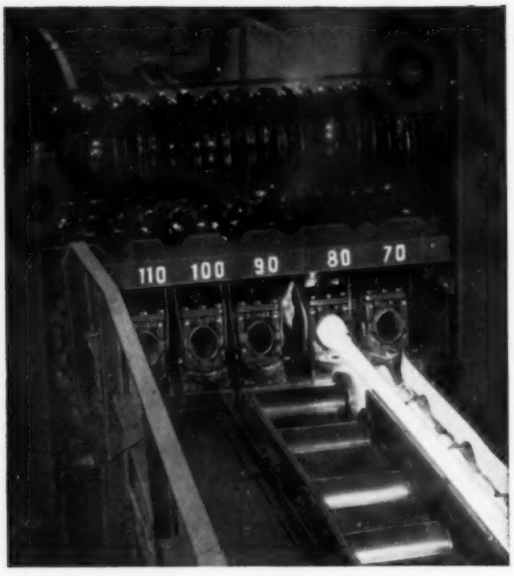
Another important "first" for Automatic engineering...this attachment eliminates the necessity for separate up-ending units in handling steel coils weighing up to 60,000 lbs. Flexibility in handling and storage is substantially improved and usefulness of the heavy duty ram truck is correspondingly increased. The coil is held securely, at any stage of rotation with a minimum of pressure, eliminating damage to coils.

This unit is now available on the new Automatic HR Series electric trucks or as an attachment for any Automatic truck of suitable design and capacity. Write today for further information.

Automatic
47 West 87th Street
Chicago 20, Illinois, Dept. H-7

WORLD'S LARGEST EXCLUSIVE BUILDER OF ELECTRIC-DRIVEN INDUSTRIAL TRUCKS

8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill



Nos. 125 and 155 roller guides fitted in a 27 1/2 in. (700 mm.) diameter, three-high stand for rolling 2 3/4, 3 3/16, 3 9/16, 4, 4 3/8 and 4 7/8 in. (70, 80, 90, 100, 110 and 124 mm.).

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

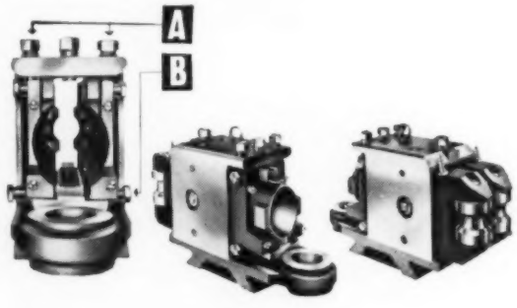
2 The rollers are mounted on leaf springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be thick, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.



7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and drawing oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mill. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

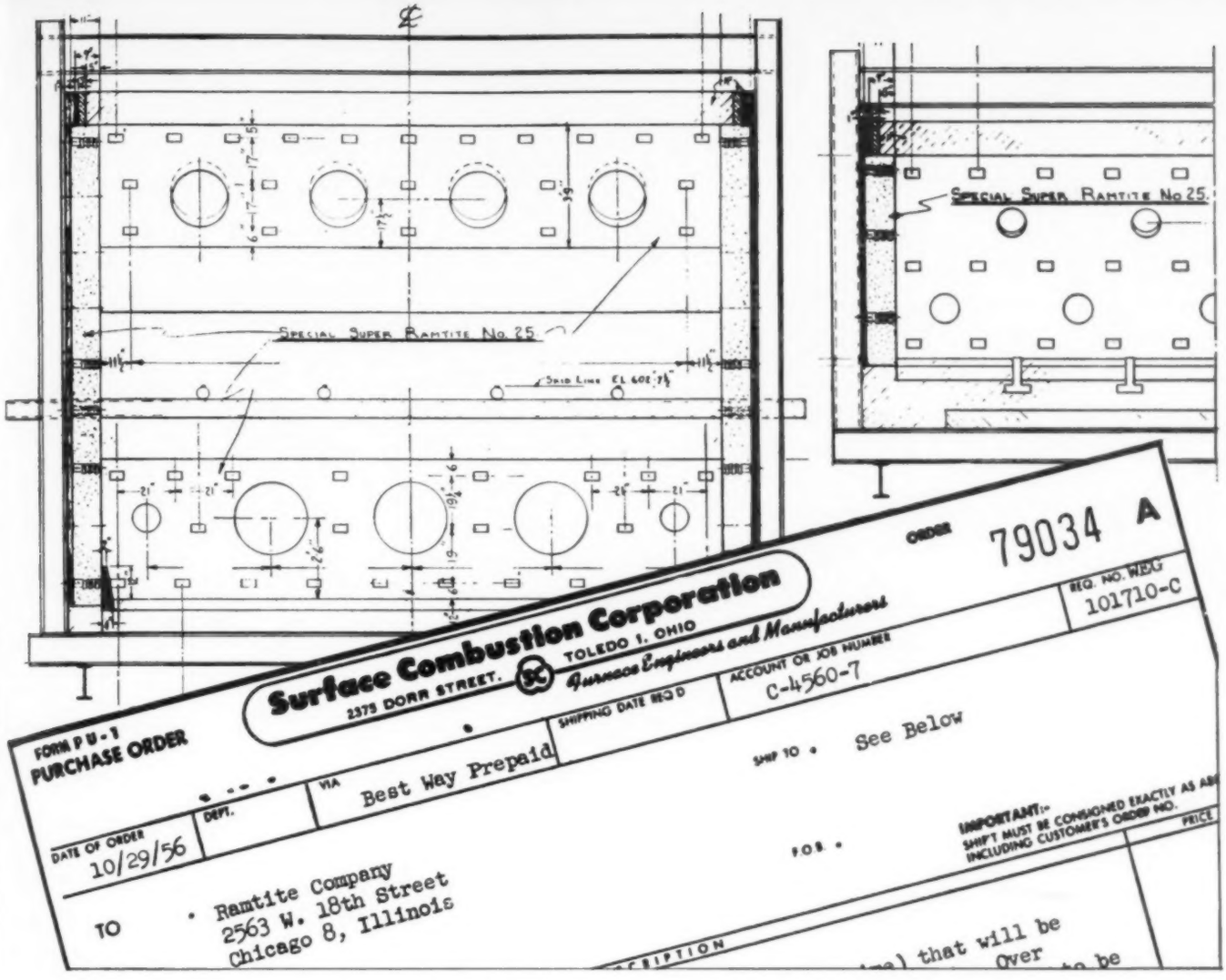
PS *Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.*

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK VERKSTADS AB • MORGÅRDSHAMMAR • SWEDEN

SOLE AGENT FOR THE US:
K.W. Atwater Engineering, Inc.
401-03 Butler Street
Pittsburgh 23, P.A.

Telegrams: Morgårdshammar, Ludvika. Sweden



Four more NEW Surface® slab heating furnaces with RAMTITE® side and burner walls

In slab heating furnaces as in other steel mill applications, it's performance that counts. We feel that is the reason for the ever increasing use of Ramtite by steel mills and furnace designers throughout the nation—and for the above purchase order for Ramtite to line the side and burner walls in these new 135 ton triple fired furnaces.

Ramtite performance in similar furnaces has resulted in:

1. *Increased furnace capacity*—high thermal efficiency permits a 25% to 30% reduction in thickness over standard wall construction.

2. *Fuel savings*—monolithic construction eliminates joints, reduces air and gas leakage as never before.

3. *Low maintenance*—inherent spall resistance assures longer refractory life.

The Ramtite Co. offers you a complete sales engineering service—experienced men who are always available to study your refractory problems and consult with your engineering, mason and ceramic departments about your specific needs.

For further information, contact your local Ramtite representative or mail the coupon below.

Ramtite is our business . . . not a sideline.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send items checked

- ☐ Bulletin on Casting and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name _____

Attn. Mr. _____ Title _____

Address _____

City _____ Zone _____ State _____

© 1957 This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

252 (L)
AHEPA

The New One. Battery No. 9, installed by Koppers last year, consists of 41 Koppers-Becker underjet ovens capable of producing 700 tons of furnace coke a day.

Below, ovens are pushed on a fixed 17-hour schedule.

294 KOPPERS COKE O

THE NEW NO. 9 COKE BATTERY at Weirton Steel Company went into operation in November, 1956. These 41 Koppers-Becker underjet ovens and five previous batteries, all designed and built by Koppers, give Weirton a total coke-producing capacity of 1,900,000 tons per year.

There are good reasons why Weirton Steel Company, a division of National Steel Corporation, has always called on Koppers for coke plant design and construction. Koppers has been improving coke ovens since 1907—reducing operating costs, increasing the yield of chemicals, improving control of heating. These improvements can be measured in dollars—dollars saved where Koppers ovens are installed.

No Decarbonizing Equipment

Koppers-Becker underjet ovens eliminate the need for decarbonizing equipment because waste gas is recirculated to inhibit carbon formation in flues and in gas ducts. This also cuts fuel gas consumption.

KOPPERS

. . and another new battery makes

E OVENS AT WEIRTON STEEL!

Koppers ovens provide unusually even coke temperature from top to bottom and from door to door. The result is extremely uniform coke.

Plant Layout and Design

Koppers research and engineering staffs can tailor designs and plant layouts to your needs . . . can help you with all problems connected with coal preparation and handling, coal-chemical recovery, light-oil refining and purification, phenol recovery, and other processes associated with coke plant operations.

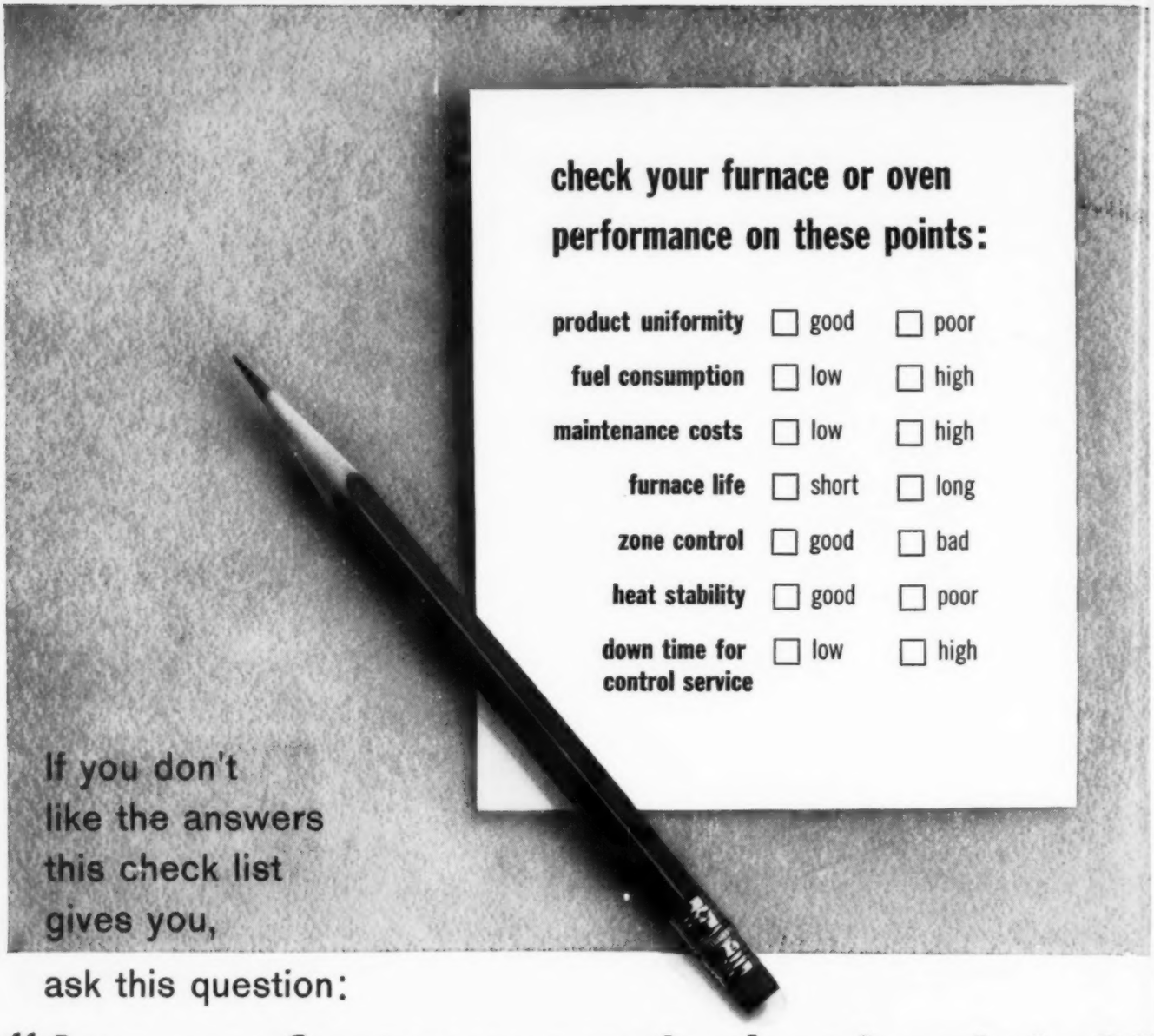
• • •

Call Koppers for *any* type of steel-mill installation. Engineers from the Coke Plant Department, Freyn Department, and Chemical Department are prepared to work with you during all phases of plant construction, expansion, or rebuilding. Koppers Company, Inc., Coke Plant Department, Pittsburgh 19, Pennsylvania.

Weirton Ovens are 100% Koppers. Every coke oven built for Weirton Steel Company has been built by Koppers. In this photo are batteries 5, 6 and 8 . . . with 147 Koppers ovens in line.

KOPPERS

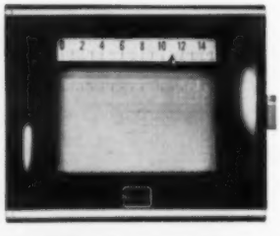
ENGINEERING AND CONSTRUCTION


check your furnace or oven
performance on these points:
product uniformity ☐ good ☐ poor
fuel consumption ☐ low ☐ high
maintenance costs ☐ low ☐ high
furnace life ☐ short ☐ long
zone control ☐ good ☐ bad
heat stability ☐ good ☐ poor
down time for control service ☐ low ☐ high
If you don't like the answers this check list gives you,

ask this question:

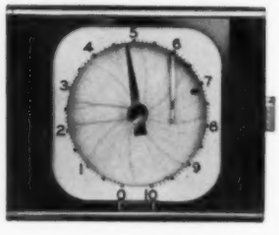
"Are my furnace controls obsolete?"

Strip-chart model



BRISTOL DYNAMASTER* ELECTRONIC PYROMETER CONTROLLERS

Round-chart model



Outmoded instruments can cost you money, lower product quality, and cut output of any furnace or oven.

New Bristol ideas are revolutionizing many older concepts of automatic control. *Bristol's great strides in electronic potentiometer development have made obsolete many instruments only a few years old.*

New product developments and production methods are placing new and unusual demands on furnace instruments and controls today.

That's why it pays to find out about the latest Bristol engineering developments before you buy another instrument or control. Take Continuous Standardization, for example—a feature you'll want on *your* next pyrometer controller. This exclusive Bristol feature, found only on Dynamaster* Pyrometers, eliminates dry cells but retains the accuracy-insuring standard cell. There's no interruption to control for standardization; no batteries to replace.

Continuous Standardization is just *one* recent Bristol development in the field of pyrometry and temperature control. To find out more, write: The Bristol Company, 123 Bristol Road, Waterbury 20, Conn.

7.16

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

*T. M. Reg. U. S. Pat. Off.

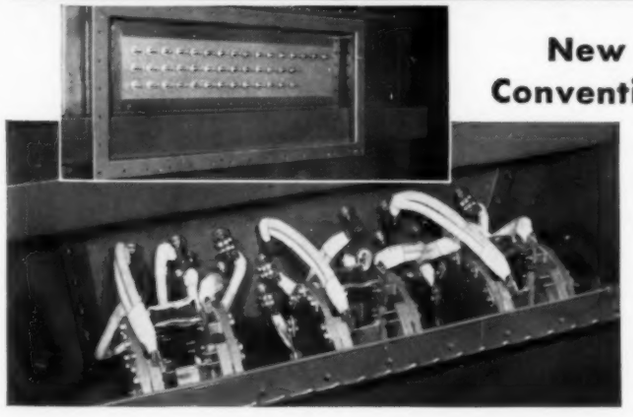
TAP-CHANGING downtime reduced from hours *to minutes!* That's the profit advantage you get with the improved tap-changing arrangement on Allis-Chalmers furnace transformers. Tap leads are brought directly to a motor-operated tap changer housed in a *separate* compartment. The ease with which taps can be changed is the secret behind the outstanding time conservation.

Advantages of Separate Compartment Located On the Side

- Affords convenience of changing taps from floor—eliminates hazards associated with top-of-transformer work.
- Eliminates possibility of objects dropping into tank.
- Reduces height of tank by eliminating terminal board.
- Main tank need only be opened for periodic inspection.

Furnace Transformer

Tap Sequence Changed in Minutes!



New Selectoheat Arrangement Eliminates Conventional Multi-Position Terminal Board

All primary taps are brought out of the main tank through a panel to the tap changer compartment. Panel completely isolates compartment from main transformer tank.

Get all the facts. See your A-C representatives or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

Selectoheat is an Allis-Chalmers trademark.

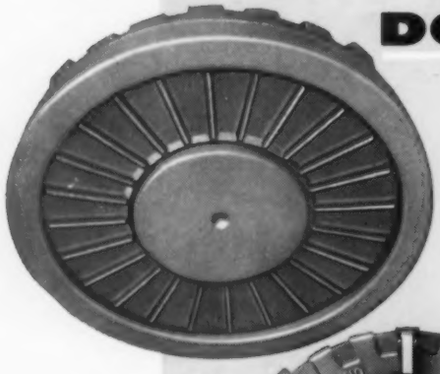
ALLIS-CHALMERS

A-C ALLIS CHALMERS

A-5391

No Wonder this EC&M Magnet

DOES THE JOB BETTER!



EC&M Type SW All-Welded Lifting Magnets have a new look ...inside as well as outside! They're stronger and better designed to withstand the hard knocks encountered in magnet operation. They're easier to maneuver. And through high-lifting capacity they reduce handling costs.

The magnet-coil is wound between turns with purer, thinner asbestos tape. Its strength has been increased by impregnation with EC&M No. 281 compound. Between layers is a new insulation product, ECAMICA board, which is moisture-free, has high dielectric strength and excellent mechanical ability. A new fabricating process locks the windings against movement.

EC&M magnets are ALL-WELDED to keep pole shoes tight, to keep moisture out, to increase the efficiency of the magnetic circuit and to prolong magnet life.

Write for Bulletin 900

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

7408

Replacement costs take a plunge...when you use pickling baskets of corrosion-resistant Ampco* Metal

AMPCO Metal's high resistance to most corrosive pickling solutions means money saved for you. It means that pickling baskets stay on the job longer, when made of Ampco Metal. It means less time spent for maintenance, repairs, replacement. And Ampco Metal's toughness, coupled with its ability to withstand corrosion, means that you get long, low-cost performance all through your pickling line — from strip rollers, crates, chains, and yokes.

And there's more! Ampco Metal has remarkable wear resistance, and high impact and fatigue strength. It saves time, constant replacement costs, and expense in such applications as screw-down nuts, slippers, and flash-welder dies.

Let versatile Ampco Metal help you cut costs, improve production. Get complete details from your nearby Ampco field engineer or write us about your tough wear or corrosion problems.

*Reg. U. S. Pat. Off.

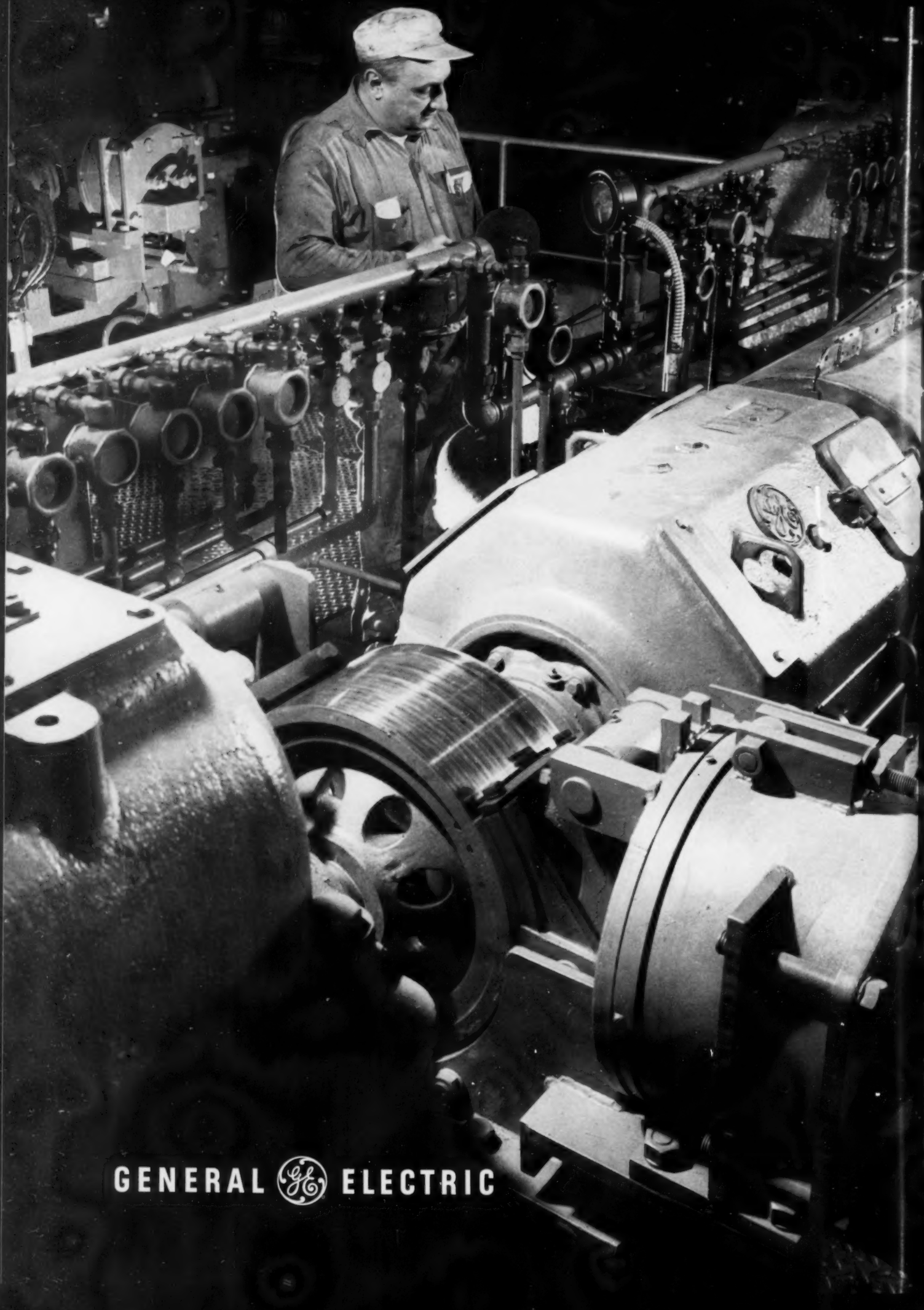
AMPCO ®

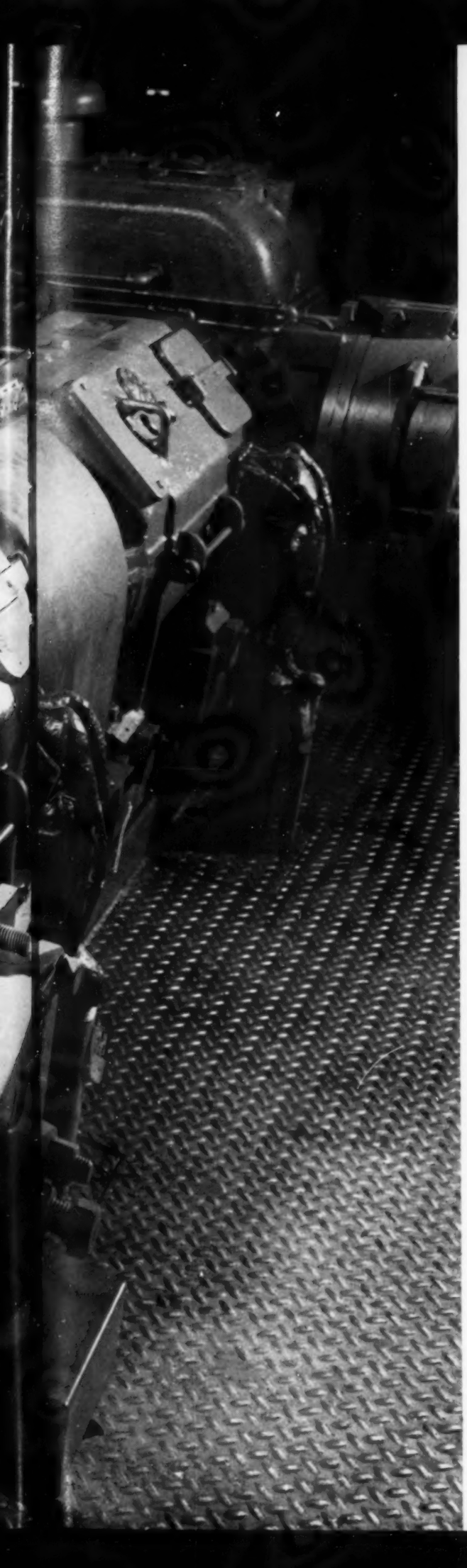
AMPCO METAL, INC. G-21

DEPT. IS-6, 1735 S. 38TH STREET

MILWAUKEE 46, WISCONSIN

West Coast Plant • Burbank, California


GENERAL ELECTRIC



Progress in Direct Current Drives . . .

NOW MD-600 Motors Meet AISE Standards In All Sizes

In steel mills, on cranes, on power shovels—on any application where severe operating conditions exist, General Electric's Armored Motors are on the job. ***In all frame sizes***—402, 602 through 624, MD motors meet or better the high standards of the Association of Iron and Steel Engineers.

Where minutes mean money—In the process industries, any "downtime" can cause staggering losses. MD-600 motors have that ***added protection*** that gives steadier production—fewer unplanned shutdowns.

Class H insulated coils, standard in all MD-600 motors, give greater thermal protection, longer insulation life—an unmatched level of dependability. Insulation failure and motor roastouts have been virtually eliminated!

Specifically designed for the most rugged production applications, General Electric MD-600 motors provide high acceleration, deceleration and reversing to deliver peak horsepower faster and more efficiently. They will perform continuously under extreme strains of mechanical shock, high temperature and in the corrosive presence of dirt, steam and water.

Engineering help—If you would like to know more about the MD-600 motor line, we would be pleased to have a General Electric Industrial Specialist call on you. Or, if you prefer, we will send you copies of GEA-5654. Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania. 811-4

Progress Is Our Most Important Product

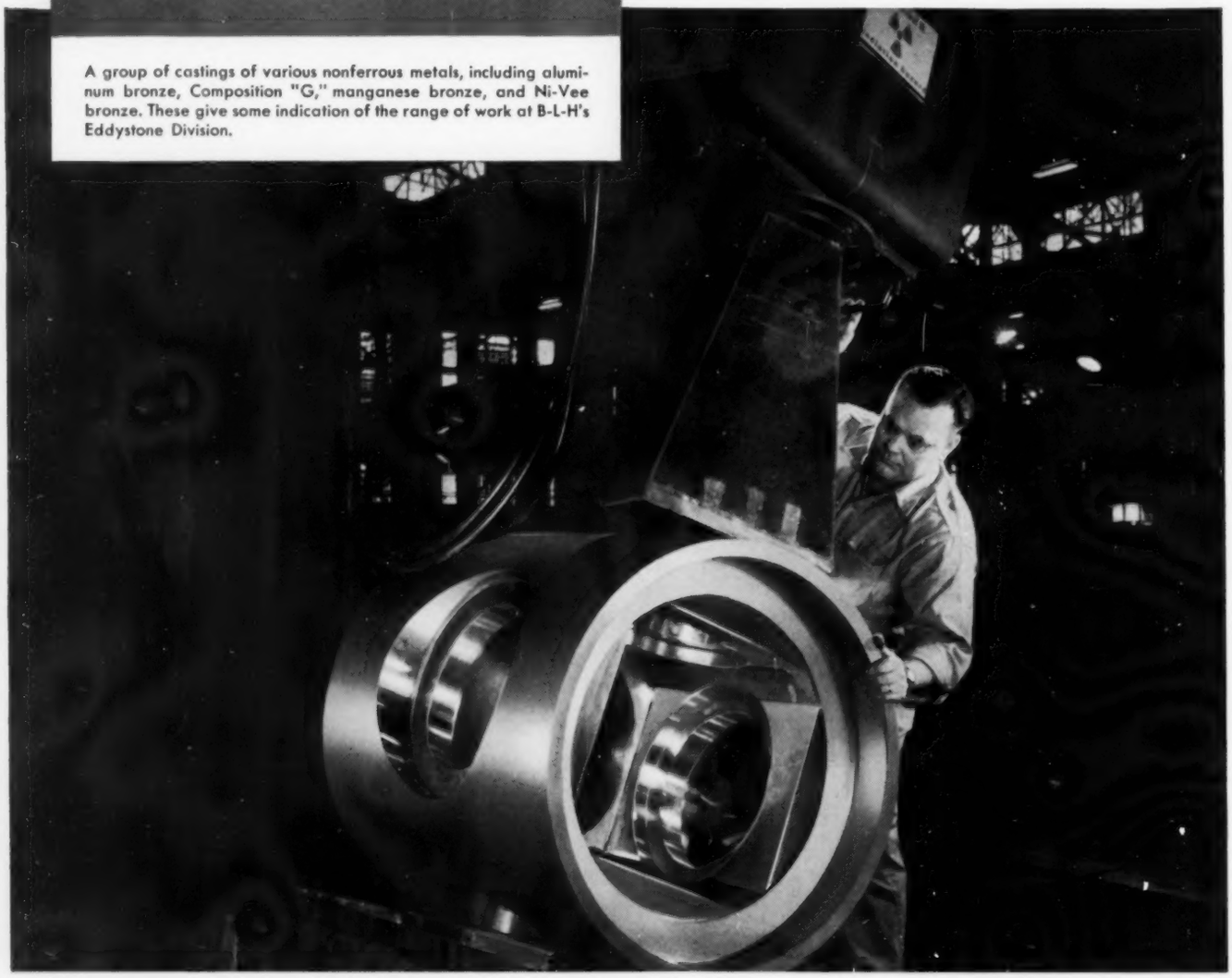
GENERAL ELECTRIC

Baldwin X-rays castings to insure strict quality control

A group of castings of various nonferrous metals, including aluminum bronze, Composition "G," manganese bronze, and Ni-Vee bronze. These give some indication of the range of work at B-L-H's Eddystone Division.

At Baldwin, quality control is not something we merely pay lip service to. Completely equipped chemical and physics laboratories enable us to make it a tangible, vital part of our services. When specified, we subject your castings to rigid X-ray examination and we are thus able to assure you of their quality. In addition to X rays, we also employ the electron microscope and the spectroscope where specified.

Job shop or high production foundry work, castings of many alloys and compositions weighing from ounces to 95,000 pounds . . . whatever your needs, Baldwin can satisfy them. For a copy of our illustrated Foundry Bulletin 6002, write us today.



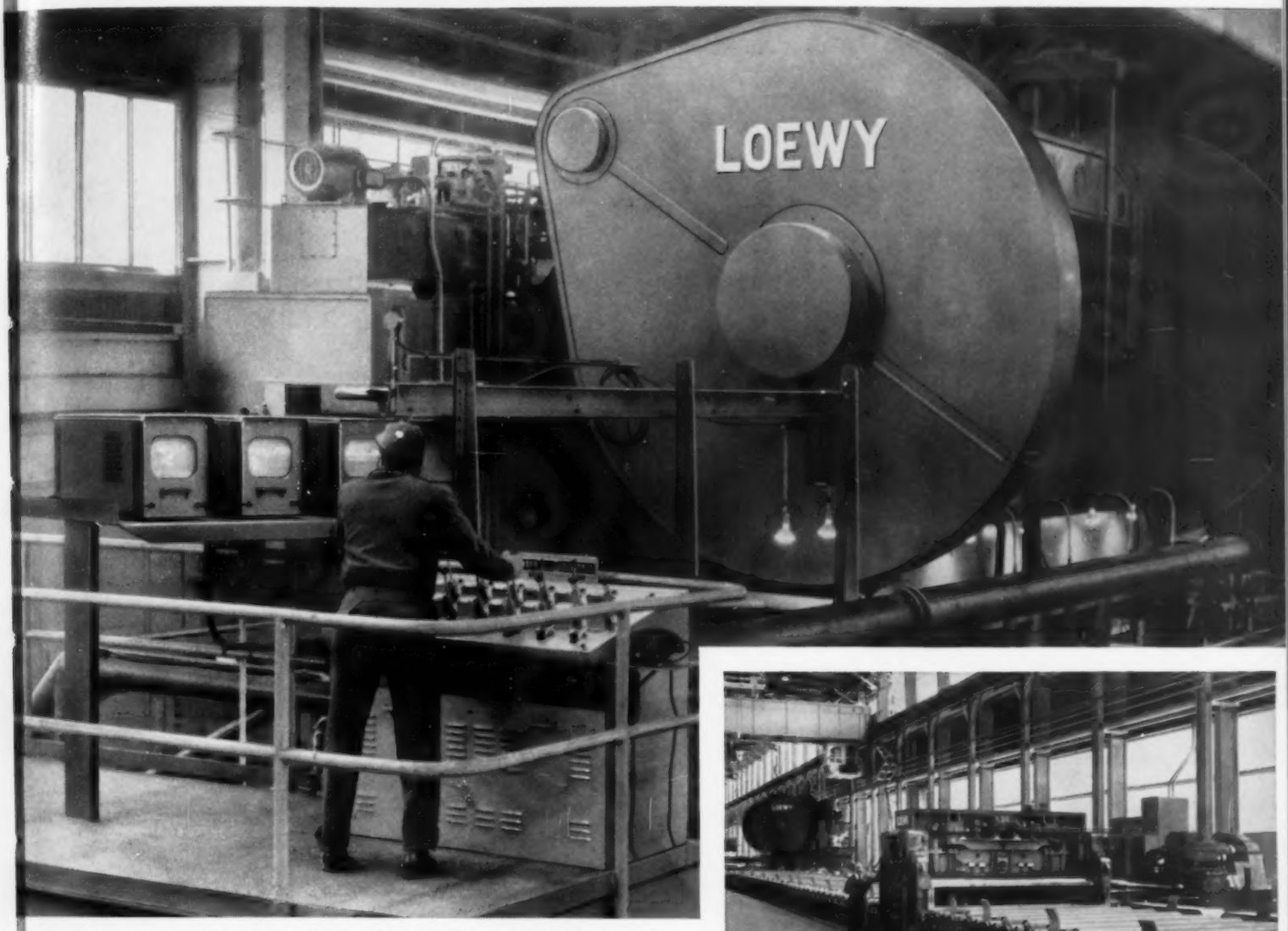
Hub of a controllable pitch propeller under the eye of a 220 kvp, 9 milliampere General Electric mobile X-ray unit at the Eddystone Division of B-L-H.

BALDWIN · LIMA · HAMILTON

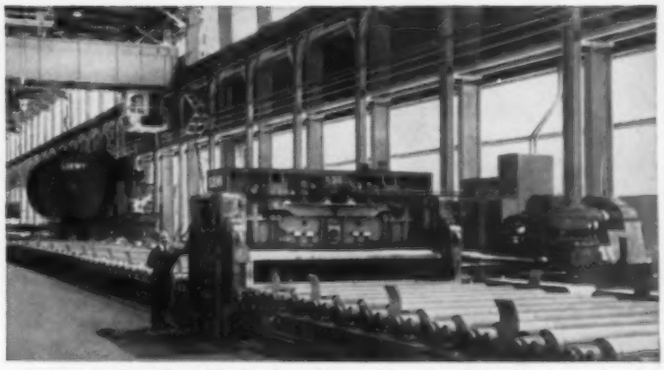
Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings



Loewy-Hydropress alloy steel plate shear with completely mechanized, one-man-operated plate manipulator at the Lukens Steel heat treating plant, Coatesville, Pa.



Loewy designed and built shearing and leveling line at Lukens Steel.

At Lukens Steel . . . one-man-controlled alloy steel plate heat treating and shearing installation

The 800-ton-capacity alloy steel plate shear shown above is part of a complete Loewy-Hydropress shearing-leveling and mechanized plate-handling installation at Lukens Steel's Coatesville plant, considered the most modern alloy steel plate heat treating facility in the United States.

By means of a specially developed plate manipulator —a truly mechanized handling system—the need for manual plate handling has been eliminated. One shear performs all cutting operations in succession. It is capable of cutting up to 1¼-in.-thick alloy steel plate. All movements for cutting four sides of the plate are remote-controlled by one operator who moves it into the shear, lines it up with the aid of a TV circuit, and then accurately cuts it to size.

This Loewy-Hydropress installation is another outstanding example of the advanced auxiliary equipment so vital to a really integrated mill operation.

Loewy-Hydropress, builder of all types of rolling mills, also designs and builds roller-straighteners, levelers, manipulators, individually driven motor rollers, ingot pushers and tilters, transfer tables, mechanical cooling beds, and other auxiliary equipment to the customer's individual requirements. The vast, integrated facilities of Baldwin-Lima-Hamilton enable Loewy to speed the delivery of this equipment.

Write us today, Dept. C-6, for further information.

Loewy-Hydropress Division

BALDWIN · LIMA · HAMILTON

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

BALDWIN BLH LIMA-HAMILTON

for smooth power

. . . CONE-DRIVE gearing has no equal.

You can drive the most delicate equipment or the heaviest industrial machinery without vibration or noise through a set of Cone-Drive gears.

Smooth delivery of power is an outstanding feature of Cone-Drive double-enveloping worm gearing. It's the result of a unique design that puts one-eighth of all gear teeth in simultaneous, full-depth contact with the worm threads.

The contact between teeth is "area" rather than the line or point type contact found in cylindrical worm gearing. This distributes the load over more area on each tooth to boost load-carrying capacity.

Want smooth, chatter-free, efficient power in a compact package? Cone-Drive gears will give it to you in gearsets or speed reducers in a wide range of models and sizes.

Ask for Bulletin 600-C for details.

CONE-DRIVE GEARS

Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

What one form of power is cheaper today than in 1940?

Electricity. And if you operate electric industrial trucks, the cost is probably less now than when you bought them.

Isn't this a refreshing contrast to the rest of today's business-cost picture? And isn't this something to think about for the future? Other costs keep going up, up, up. But electricity has been coming down, down, down—for years.

The result is that electric industrial trucks are a better power bargain today than they've ever been. And power savings plus overhead savings actually total hundreds of dollars per truck every year. This has been proved in thousands of cases in all types of truck service.

Here's how you save: You buy the power from your local electric company at low rates. Heavy duty storage batteries last for years without replacement. Cool-running electric motor-drive systems that seldom need maintenance—use no power at all when standing still. While first cost is higher, electric industrial trucks give you more than twice the useful life, according to national average figures. And it's a fact that of all the electric industrial trucks ever made in the U.S., about 90% are still on the job! That's real proof of service.

These are important cost considerations for up-to-date management men today. In addition, electric industrial trucks are easier to operate and make practically no noise—advantages especially appreciated by plant personnel. Have a talk with your nearby industrial truck dealer or salesman. He's listed in your classified telephone directory under "Trucks—industrial."

This message is presented as a service to industry by Exide Industrial Division, The Electric Storage Battery Company, Phila. 2, Pa.

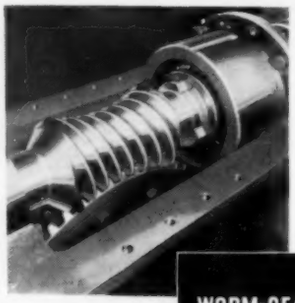
THE ELECTRIC STORAGE BATTERY COMPANY **Exide**®

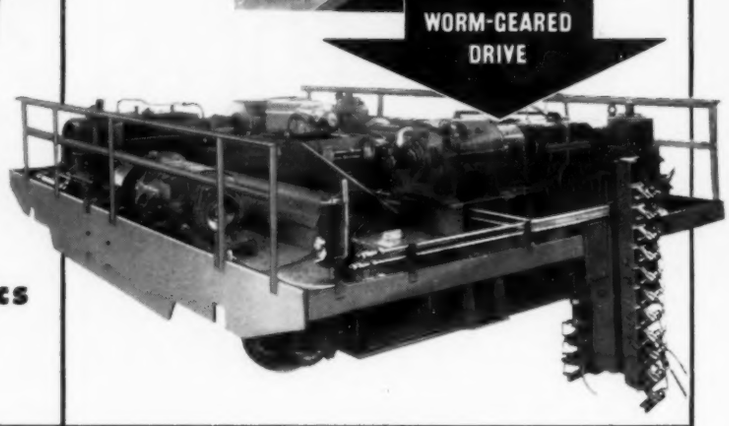
CHOOSE THE TROLLEY

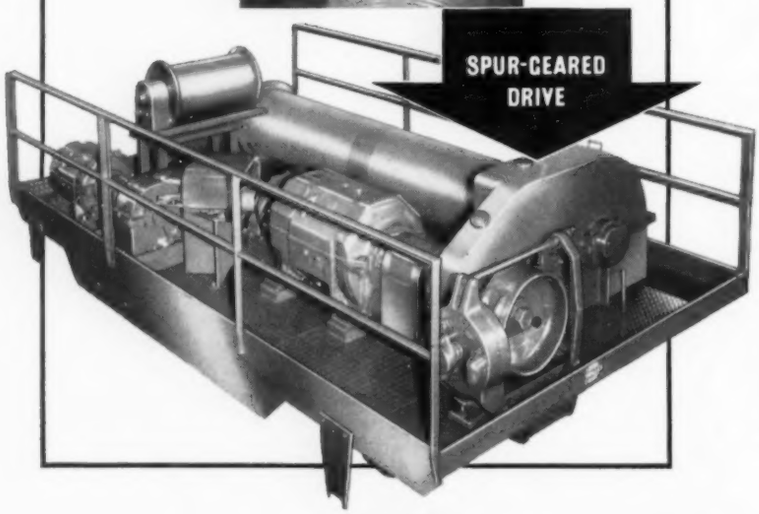
YOU LIKE BEST

SHAW-BOX

Builds both to A.I.S.E. Specs







You want trolleys of the type your experience has proved are best for your particular requirements. The two types of trolleys and their gearing shown here illustrate how A.I.S.E. specifications are interpreted by Shaw-Box in satisfying the needs of two different mill applications.

Whether you prefer worm or spur gearing on your trolleys, turn to Shaw-Box and be sure of the finest in precision manufacture. Our long experience in designing, engineering and building load handling equipment exclusively assure you of continuously dependable performance, regardless of service conditions.

Over the years, we have produced many 5 to 200-ton cranes of various types to A.I.S.E. specifications and to the specifications of individual mills. Their work records prove the economic value of mechanical and operational features conceived and introduced by Shaw-Box. So if your plans include a crane to handle plate or slabs, a soaking pit carriage or a giant ladle crane, we invite your inquiry.

57K-1

"Shaw-Box"® CRANES

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

MANNING, MAXWELL & MOORE, INC.

SHAW-BOX CRANE & HOIST DIVISION

388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

In Canada: ***Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.***

Save by using specialized refractories

Many refractories problems in metal-working furnaces have been solved *economically* by the use of B&W specialized refractory castables. Each ferrous or non-ferrous furnace application requires a specific combination of properties to meet the service conditions. Whether your problem is high temperatures, abrasion and erosion, slag attack or the need for insulation, to name a few, you will find the refractory castable best suited to your requirements in B&W's line. Shown here in digest form are data on the widely used B&W refractory castables for metal-working furnaces:

B&W Refractory Castables for Metal Working Furnaces

	Temp. F	PROPERTIES	TYPICAL APPLICATIONS
B&W Kaocast	3000	High resistance to spalling and slag attack. Low volume change and negligible reheat shrinkage.	Soaking pit covers, linings of high temperature heating and forging furnaces, burner blocks, electrode linings of electric furnace roofs, linings of non-ferrous metal furnaces.
B&W Kaocrete 32	3200	High strength, exceptional refractoriness, unusual volume stability, excellent resistance to spalling.	Can be used in applications similar to those of B&W Kaocast and where higher refractoriness is required.
B&W Kaocrete D	2500	Sufficient strength and hardness to withstand abrasion, considerable physical abuse and erosion.	Aluminum melting furnaces, linings and car tops in heat treating furnaces, as well as in sections of a wide variety of furnaces that are subject to scraping by hand tools or other mechanical abuse.
B&W Kaocrete A	2600	Resists reducing atmospheres. Has good resistance to erosion, abrasion and thermal shock.	Annealing furnace bases and other applications where resistance to reducing atmospheres is essential. Also as a general purpose castable for linings in medium temperature service.
B&W Kaocrete B	2300	Has an adhesive plastic texture particularly suited for vertical or overhanging constructions. Excellent for plastering.	Patching linings and baffles and for any application where plastering rather than gunning or casting is required.
B&W Kaocrete LI	2700	High alumina content, exceptionally high strength for resistance to abrasion and erosion.	Aluminum furnace linings where high alumina content is important.
B&W Kaolite 20	2000	Offers castable's fast, low cost installation plus insulation. Has refractoriness, light weight and low heat conductivity and, in addition, will resist reducing atmospheres. Can be poured or gunned.	Aluminum melting, heating and heat-treating, annealing and forge furnaces. Also for general maintenance and patching.
B&W Kaolite 22	2200	Has the same properties as B&W Kaolite 20. Can be used for higher temperatures but not in reducing atmospheres.	

Send for your copy of B&W Bulletin R-35. It gives additional information on B&W's versatile refractory castables.

B&W REFRACTORIES PRODUCTS: B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

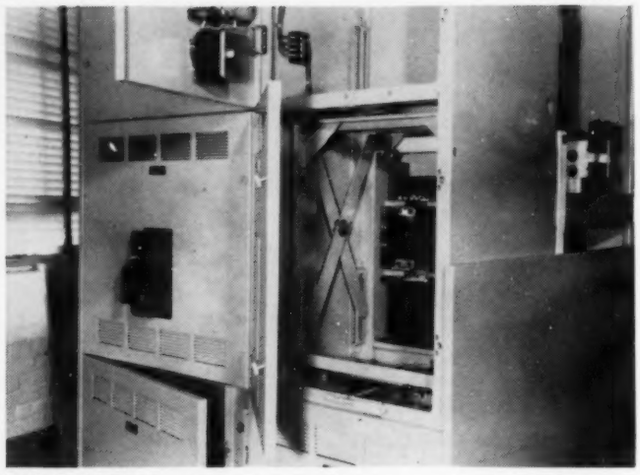
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

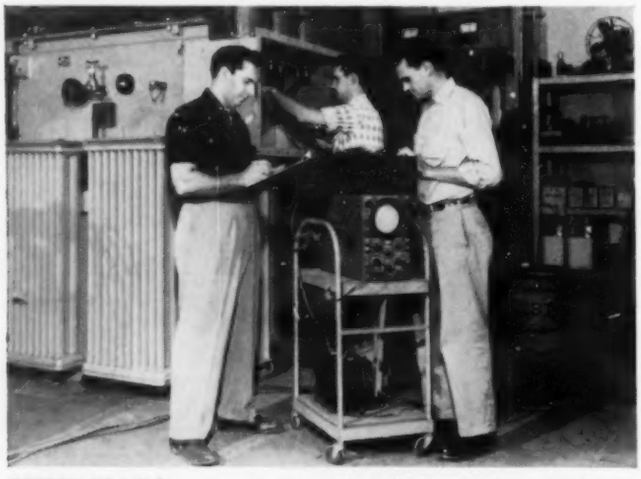
R561

SECONDARY UNIT SUBSTATIONS

ENGINEERED AT I-T-E and coordinated to meet the operating conditions found in your plant.



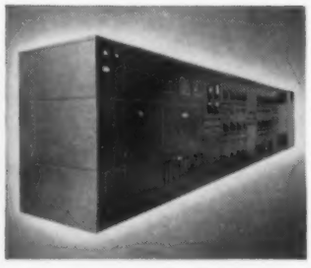
BUILT AT I-T-E with such extra features as circuit breaker test-position with doors closed.



TESTED AT I-T-E to assure ease of installation, and top performance under operating conditions.

SHIPPED FROM I-T-E to assure prompt delivery of one complete "package," ready to install.

I-T-E MAKES IT EASY TO BUY COMPLETELY COORDINATED UNITS

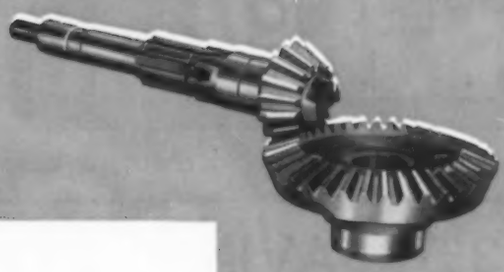


Only I-T-E builds transformers and switchgear in the same plant. This permits them to assume all responsibility for your unit substation requirements. Close association of engineering and production relieves you of detailed planning, paperwork, and the problems of coordinating deliveries. Shipment is from one location. Installation is speeded. Substation components are completely integrated to provide top performance at low overall cost.

Typical of the extra value which *only* I-T-E Unit Substations offer is circuit breaker test-position with doors closed—and without removing them. This means additional safety to operating personnel, greater cleanliness, simplified tagging out of circuits, and longer life. I-T-E Secondary Unit Substations can be supplied for any application, indoor or outdoor, and in any standard rating. For details, contact the I-T-E sales office nearest you. Or write I-T-E Circuit Breaker Company, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division

IN CANADA: EASTERN POWER DEVICES, LTD.

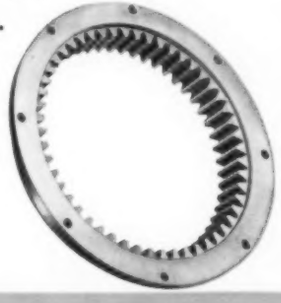


Quality with a pedigree

Every year more and more users of gears who demand the highest quality are turning to ILLINOIS GEAR to meet the exacting needs for this very important part of their equipment or machinery.

They have come to know and depend on ILLINOIS GEAR — a company with a rich heritage in the manufacture of quality gears . . . *from whose modern plants come the most complete line of gears in the world!*

If you use, specify or buy gears for any purpose — look to ILLINOIS GEAR as your most complete and dependable source.



Look for this mark ILL-G® *the symbol on finer gears*

ILLINOIS GEARS Reg. U.S. Pat. Off.

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

THE BROOKS OIL CO.

Lube-Engineering News

A REPORT ON THE DIFFICULT LUBRICATING PROBLEMS OF INDUSTRY

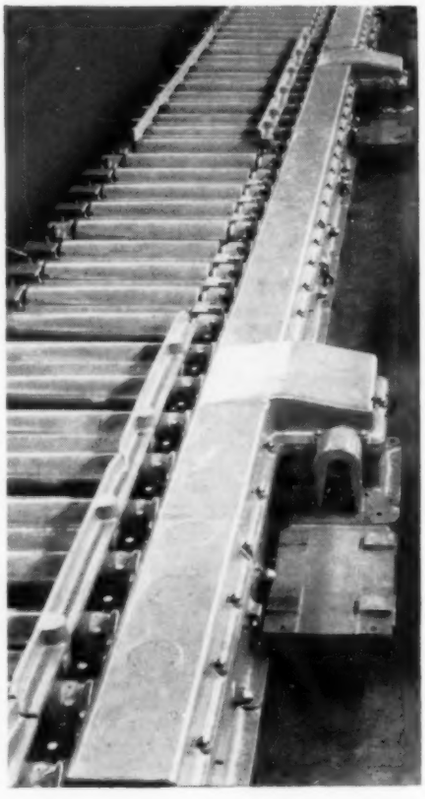
93% SAVING IN MILL TABLE LUBRICATION COSTS REPORTED BY LEADING STEEL PRODUCER

A leading steel producer recently went through a series of corrective measures to improve lubrication of mill tables. They went from circulating oil system to pressure grease system and finally to automatic spray system.

In the spray system, they used Brooks Klingfast and reported a saving of 93% in lubricant cost. They do not attribute the saving to the change in equipment, as various lubricants were tested. Klingfast offered the greatest reduction in lubricant cost for the application.

Records indicate a 35% decrease in man hours spent on this lubrication job, and 65% less maintenance delays due to improved lubrication. Klingfast has proved itself against adverse conditions of mill scale, water and high temperatures. Savings in maintenance costs were coupled with increased production.

For full information, write for Engineering Letter 73IS.



NEW COLOR FILM AVAILABLE TO LUBE-ENGINEERING GROUPS

This new 30 minute 16 mm motion picture, in full color, with sound, shows a number of tough lubrication jobs. It pictures and describes the research, manufacturing and quality control methods that enable Brooks lubricants to "stand up" under severest service.

It's available to any supervisory or engineering group interested in lubrication problems. No charge, of course—we're glad to have you see it. Just call or write any of our offices and tell them you want to borrow "The Brooks Oil Story."

CIRCULATING OIL SYSTEMS REQUIRE LUBRICANTS THAT WITHSTAND SEVEREST SERVICE CONDITIONS

Dust, dirt, water and metallic contamination present extremely difficult problems for circulating oil system lubricants—in steel mills, forging and press shops, cement plants and many other industries. Lubricating compounds must withstand constant contact with contamination, readily dissipate such foreign matter and maintain quality for continued service.

Brooks Leadolene and Klingfast are compounded to meet such severe conditions. These products have served industry since the early 30's and have broken many records. Companies in the United States and Canada have obtained 5, 10, 15 and 20 years of continued service from these lubricants. For complete facts, see your Brooks representative or write for Engineering Letter 86IS.

THE BROOKS OIL CO. 81st YEAR 1876 1957

THE BROOKS OIL COMPANY

EXECUTIVE OFFICES AND PLANT—CLEVELAND, OHIO
EXECUTIVE SALES OFFICES—928 RIDGE AVENUE, PITTSBURGH 12, PA.
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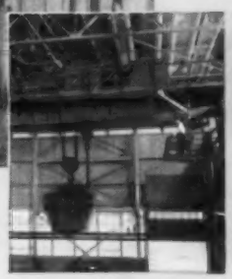

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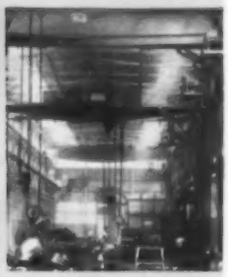

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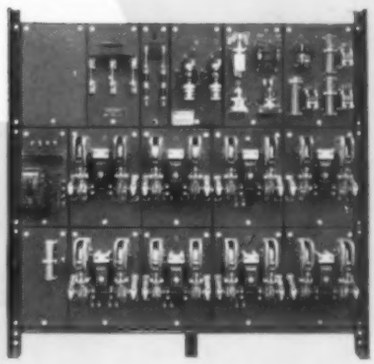

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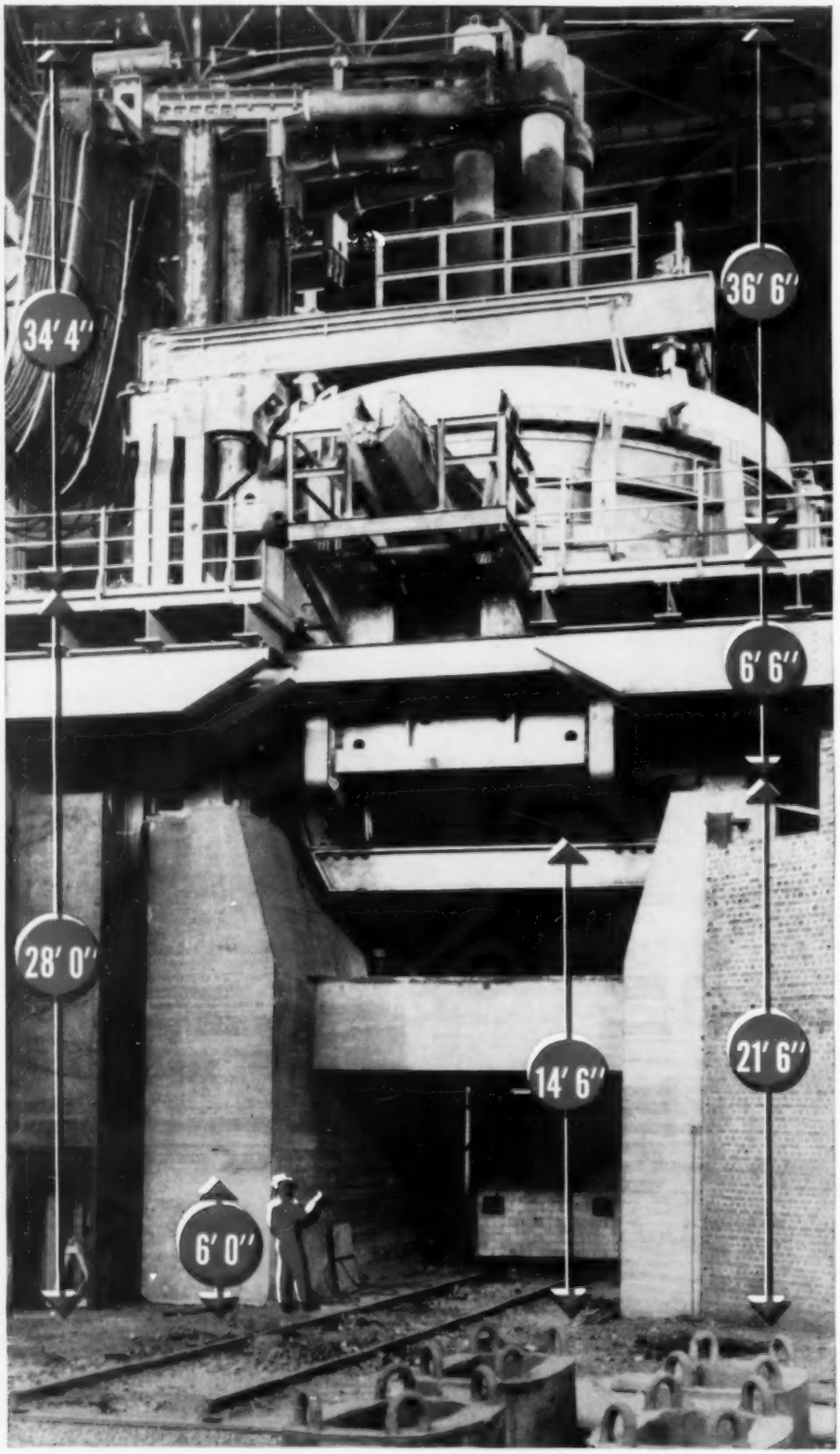

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By L. A. FUGASSI
Assistant Chief Engineer
Weirton Steel Co.
Weirton, W. Va.

▲ ON August 8, 1927, Weirton began operation of the first completely continuous wide hot strip mill with reels for coiling the hot band (Figure 1). The mill was designed for a 48-in. wide strip at a theoretical capacity of 30,000 tons per month. From August 8, 1927 to January 13, 1947, the mill rolled over 12,000,000 tons of steel.

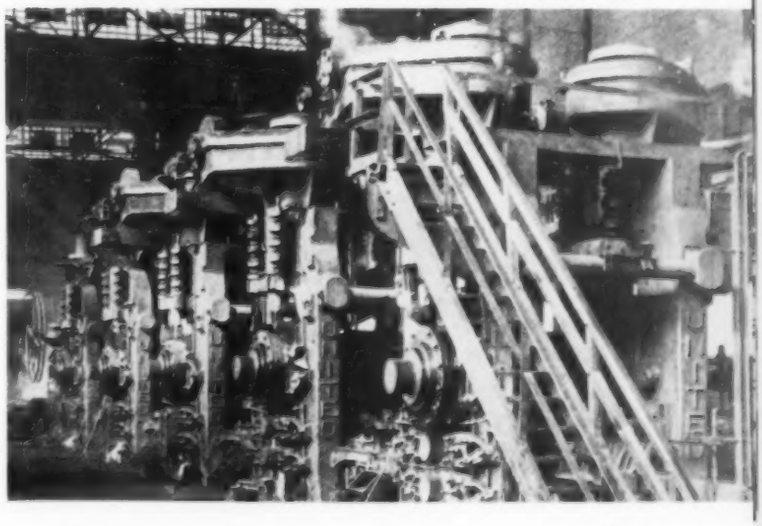
Prior to World War II, Weirton's management foresaw the increase in demand for hot rolled steel and a new wider 66-in. hot mill was purchased; but in 1941, due to war conditions, it was not feasible to lose any production time so the old mill was kept in operation.

To assist in the war effort, Weirton agreed to sell two of its new 66-in. stands to another industry which required rolling capacity for aircraft production.

In 1947, with the critical production of war behind, Weirton decided to proceed with another step in its modernization and installed the four new 66-in. finishing stands, leaving in place two of the original 48-in. finishing stands (Figure 2). On January 13, 1947, the old mill was shut down and construction of the new finishing stands and reels was begun.

A new runout table extended 258 ft from the finishing train to the No. 1 reel and the new mill handled slabs

Figure 1 — The original strip mill was designed for 48-in. wide strip and had a capacity of 38,000 tons per month.



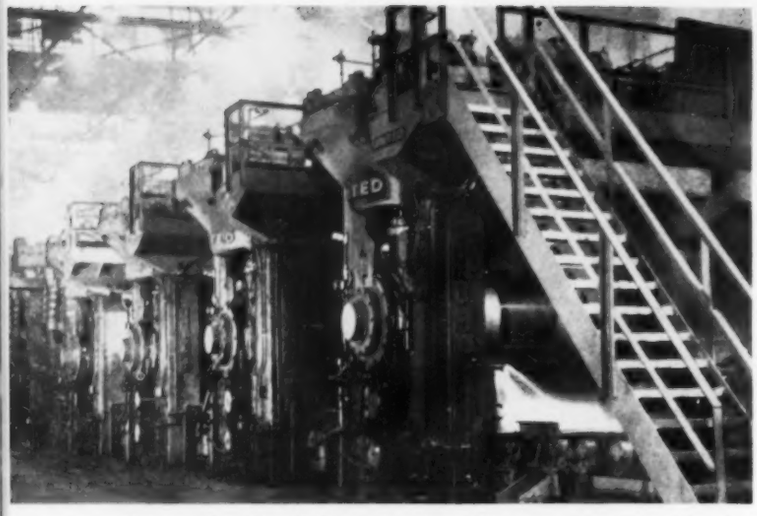


Figure 2 — In 1947 the strip mill was modernized by installing four new 66-in. finishing stands.

up to $5^1/_2$-in. thick and about 6500 lb. in weight at the rate of two a minute.

The general plan was to do in advance every part of the over-all job that could be completed without losing production on the mill. During this advance period, the mill was operated continuously to the limit of its capacity in order to build up a stock of coils that would sustain the finishing operations during the shutdown. Also it was necessary to telescope the time of actual shutdown to the shortest possible time so as not to materially affect overall production.

First came the engineering with detail drawings of all phases and a schedule to fit into the operation. Equipment and materials were procured and delivery arranged so that every last bolt and nut was on hand at the proper place when needed.

Engineering, construction, and operating departments closely co-operated in the development of the plans. Operations of the steel works, the cold mill, and the finishing departments were co-ordinated so that the flow of material could be adjusted to special circumstances as they arose. Fortunately, part of the job had already been completed when a new 100-ton-per-hour slab furnace was installed in 1945.

Figure 3 — On the 66-in. mill, coils were moved at the basement level.

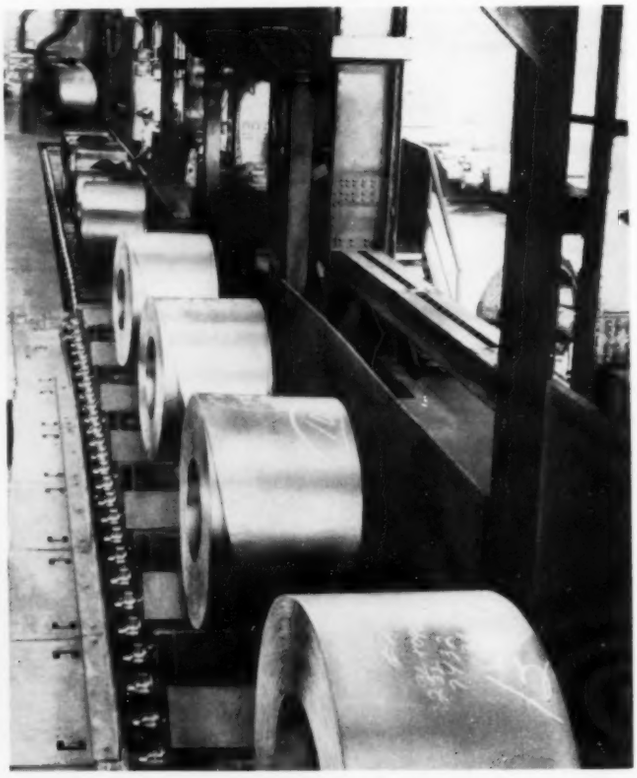
A rough outline of the procedure was as follows:

1. Dismantle and remove six stands of the 48-in. finishing train.
2. Excavate, build forms and floor foundations for the scale-breaker and six stands of the new finishing train.
3. Excavate, finish, and equip new electrical control room.
4. Install the new 66-in. wide mill.
5. Extend the turnover table between the roughing and finishing trains.
6. Relocate all motors, drives, and pinion stands and in addition, rebore and machine pinion stands for increased pinion sizes.
7. Install a new and longer runout table equipped with a larger system of sprays.
8. Install two new reels, coil ejectors, and turndown rigs.
9. Install a new cooling conveyor, coil transfer unit and elevator conveyor.

In August of 1946, the first phase of the work was begun with the installation of the reels, coil ejector, turn-down rigs, cooling conveyor, coil transfer unit (Figure 3), and elevator conveyor (Figure 4). This was relatively easy since these items were located in an area a considerable distance below the reels of the old mill and their installation did not interfere with production. In fact, it contributed to production—because as soon as the new reels were completed, the runout table was quickly extended and all of the new facilities were placed in immediate service.

The second step was more difficult. It consisted of building foundations for the last four stands of the 66-in. finishing train, and these had to be built under the runout table and the work proceeded while the table was in constant use. As a matter of special in-

Figure 4 — The elevator conveyor transferred the coils between the basement and mill floor levels.



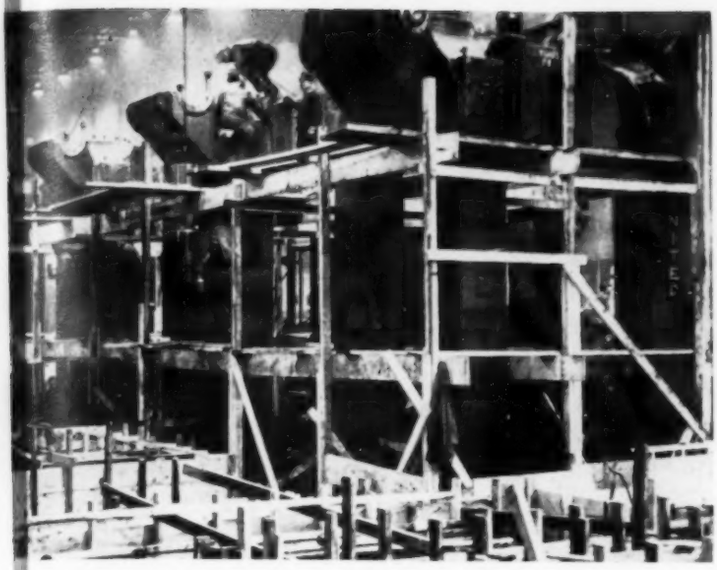


Figure 5 — The foundations were about four ft on one side of the runout table which gave enough room to install bed plates under the runout table.

terest, the problem was solved by driving a row of steel piling on either side of the runout table, starting at a point about 55 ft beyond the last stand of the old mill and extending a distance of 70 ft. The weight of the runout table was then supported on I-beams secured to this piling. Next a welded V-shape trough was fitted to the underside of the runout table to keep water from drenching the men who would be working underneath. After these preparations, the excavation was dug to a depth of 30 ft, the forms were built, and the concrete poured for the foundations of stands No. 7, No. 8, No. 9 and No. 10. All the time this work was going on, a constant succession of hot strip steel passed along the runout table over the heads of the construction crews.

Planning had determined that the 48-in. mill could be operated for a short period without the No. 10 finishing stand and permit more of the construction work to be completed in advance of the shutdown. Accordingly the No. 10 stand was removed on December 10 and the runout table was extended to No. 9 stand. With the mill in operation, the method employed to build the foundations for the last four stands was again followed in building the foundation for the No. 6 stand of the new mill.

The foundation existed beyond one side of the runout table about four feet (Figure 5), which gave just enough room to install bed plates under the runout table and the inside housings of the four 66-in. stands were mounted on the bed plates and aligned without interfering with the runout table.

Up to this point, all of the construction and installation was completed without any loss of production, but now everything was completed which could be done without closing down the mill. The last coil came off the old mill at 7 o'clock on the morning of January 13 and the real job began. Enough concrete was poured to form a foundation for a twenty-story office building. More than a 100,000 ft of conduit and 750,000 ft of wire in all sizes were installed. A total of 10,850 electrical connections were made (Figure 6). Six motor generator sets and sixty-three motors were moved and connected. The control system included 118 boards, panels and cabinets.

Approximately 1000 men worked around the clock and represented about every craft normally found in a steel mill. In addition, the operating and maintenance crews regularly attached to the mill helped throughout the job.

On January 28, just 15½ days after the old mill was shut down, all of this work was completed and the new 66-in. mill was ready for a break-in. This run continued for twenty-four hours, and on the night of January 29, four slabs were rolled to test the mill. The remainder of the night was devoted to a final tune-up and inspection and on the morning of January 30, 1947, the new mill (Figure 7) began regular production with a rated capacity of 135,000 tons per month.

To further complete the modernization of the finishing stands, the two original stands in the train, due to the sale of the 66-in. stands during the war, were replaced with new 66-in. stands and on Christmas morning in 1950, a complete six-stand, 66-in. finishing train was placed in operation.

As the demand for steel increased, Weirton's management planned its biggest expansion program and in this development was a completely modern integrated hot mill. The hot mill then operating still had the original roughing train and a revamped finishing train, and it was now necessary to revamp the entire mill. Engineering began collecting pertinent data as to the most mod-

Figure 6 — Some 10,850 electric connections were made in the mill renovation.

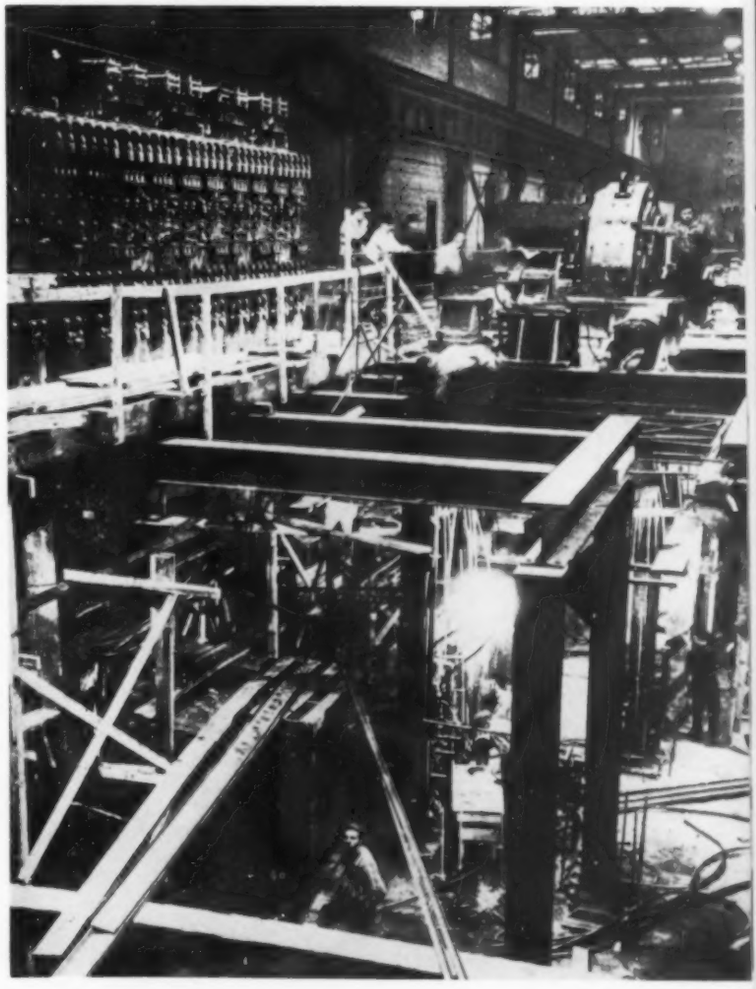


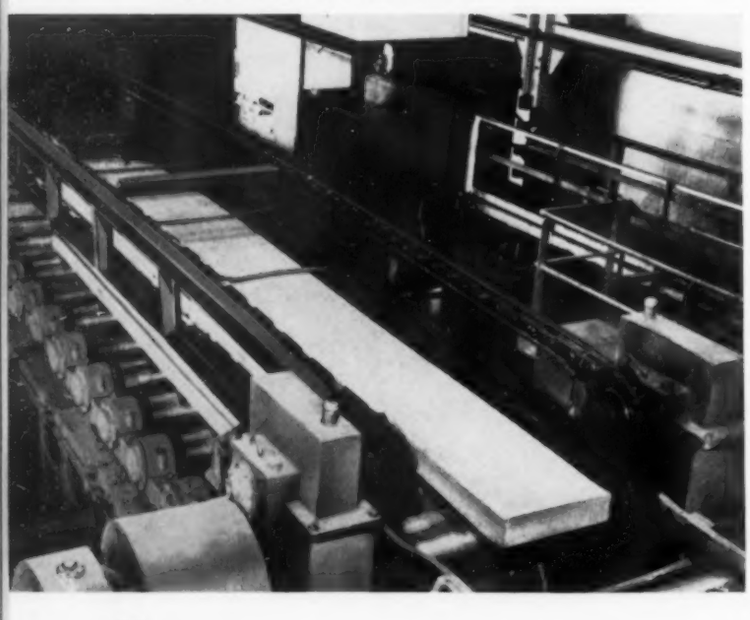
Figure 7 — Upon completion of renovation in 1947, mill had a rated capacity of 180,000 tons per month.

ern methods of rolling hot strip and again after meetings with management, operations, maintenance, the basic design was completed.

Recognizing advantages for large coils for inter-mill programs, it was decided that this mill would handle 48-in. wide x 9½-in. thick x 26-ft long slab with a weight per inch of width of 830 lb. This weight is the highest in the industry to date. The average slab now rolled is made from a 22,000-lb ingot. This slab is far heavier than the 6500-lb slab that was previously rolled and changes in the steel works practice were also analyzed to produce the new slab.

Weirton's setup had been to feed slabs from two adjacent slab yards which were at right angles to the flow of the mill, but the new planning indicated a slab yard of sufficient capacity parallel to the mill for ease in feeding slabs to the furnaces.

Figure 8 — Six slabs are placed in stacks on the elevated support and hydraulically lowered onto a roller table to prevent shock on the table.



This was an excellent idea, so the next question was where to put it. After many layouts had been analyzed and rejected, the plan finally evolved to place the entry of the mill in what was then a parking lot and an area occupied mainly by machine shops, carpenter shops, general service shops, a substation and a 1,000,000-gal water tank which were at the same elevation as the old slab yards, about 10 ft above mill floor elevation of 720-ft. This layout, in this location with slab yard elevation the same as mill floor, appeared to be the best for our needs and we proceeded on that basis. The slab yard was sized 120-ft span x 750 ft long with two 60-ton cranes.

The new mill crossed the old slab yards and interfered with about everything that was in the vicinity. Realizing that a very short shutdown period would be alloted, engineering again began the meetings for scheduling the ways and means to install this new equipment without interfering with operations. It was decided that three furnaces would be installed with a provision in the foundation tub for the future installation of the fourth furnace so as not to undermine any of the equipment if a future furnace was installed. These furnaces were designed for 200 tons per hour, each with a 28-ft hearth. The furnaces are recuperative, triple-fired, 3-zone type with a 93-ft effective length from charge door to discharge slope and are 103 ft overall and are equipped to fire coke oven gas, oil, or natural gas at about 1,000,000 cfhr for three furnaces. The stacks are 200 ft high and are self-supporting steel with brick lining.

Depiling equipment was furnished so that six slabs are placed in stacks on an elevated support and hydraulically lowered onto a roller table to prevent shock to the table (Figure 8). This lift is then run into an electric elevating depiler where a horizontally traveling bar peels the slab from the top of the pile and feeds it onto the furnace approach tables. Also provided is a cable-operated reject slab car to take rejected slabs from the furnace delivery table and redeliver them to the slab yard.

The furnaces are equipped with television cameras so that the edge of the hearth is in the view of the camera and the pusher can determine from his receiver the exact position of the slab with relation to the hearth, thus avoiding cold sides.

A 42-in. vertical edging mill with underdrive was selected as the first stand. It was then decided that three 44-in. x 54-in. two-high, roughing mills were required with stands R2 and R3 equipped with edging mills. An existing 33-in. edging mill was taken from the original No. 3 rougher of the old mill, since this edging mill was part of the 1941 purchase, and installed in the old mill in December, 1951. Also we found we could reuse two of the roughing pinion stands that had been purchased with the 1941 mill.

The fourth and fifth rougher were selected as 35-in. and 49-in. x 54-in. four highs.

Since the drives for all of the roughers were new, it was decided to add a feature to assist in roll change and accordingly an inching control was developed so that the position of the spindle tongue could be more easily set.

Realizing the importance of a holding table ahead of

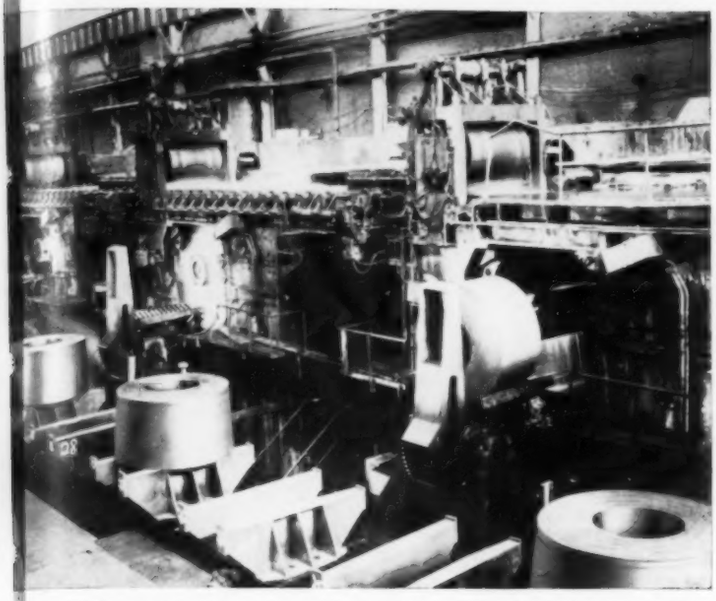


Figure 9 — It was necessary to space the coilers on 32-ft centers to handle the larger coils.

the finishers, Weirton determined on 288 ft of table between the R5 and the upcut shear for complete flexibility in handling the slab at this point.

Note this is an upcut shear. This was selected so as to crop the smallest possible end, and control yield at this point. This problem was discussed very thoroughly before the decision was reached so that the few seconds spent in stopping the slab and cropping would pay for itself in yield.

We had already installed a modern finishing train of six stands, as before mentioned, but the original design was 66-in. wide and since our thinking was now based on a 48-in. maximum width, it was decided to narrow the mill. The outside housings were moved in 12-in. and the finishing train was reconstructed to a 54-in. mill.

Fortunately the old mill had been installed with the finishing train 2 ft eastward of the roughing train due to the turnover for the old roughers. This permitted the design of the new mill to be laid adjacent to the old mill, and holding the centerline of the old roughers, it matched perfectly with the centerline of a 54-in. roll on the finishing train, thereby requiring only the relocation of outside housings on the finishing train.

This changeover was accomplished one stand at a time, and by adjusting the rolling schedule the change was made in 24 hours for each stand.

Additional horsepower was added to 8, 9, 10, and 11 finishing stands by placing a new motor in tandem with the existing motors. The armatures of the existing motors were changed to have a stronger shaft so as to transmit the full total horsepowers.

The last stand drive was removed and this mill was made a direct drive unit.

It was decided that a long runout table was necessary for metallurgical control and a distance of 426 was selected. This proved an interesting problem inasmuch as we had previously installed a run-around conveyor which carried coils from the downcoiler under the mill floor and acted as a cooling conveyor. This conveyor was approximately 600 ft long. This was a lot of equipment and we wanted to reuse it. The previous coilers were on 24-ft centers and the design of the conveyor was such that it was completely automatic, the cars being on 6-ft centers and indexed so that two coilers could load alternately and have a fully loaded conveyor. The centers between cars were increased to 8-ft to handle the larger coils. With the introduction of three coilers to load the same conveyor in sequence and keep it fully loaded, it was necessary to space the coilers on 32-ft centers (Figure 9). The space between the conveyors was too narrow at the point selected for the site of the coilers to install the necessary equipment, so a turnout was built to give operating room at the new coilers. This was also done in steps during normal shutdown periods and the foundations for the new coilers were installed by bridging the present conveyor at this area. When the new coilers were ready for operation, the runout table was bridged over the existing coilers and these existing coilers removed. The new expanding coilers are 28-in. diam., driven-mandrel type with driven wrapper rolls and can handle a 76-in. diam coil. Coils are removed from the coiler by a traveling downtilter and deposited on the car. After approximately two hours on the car, they are removed by another upender and placed on an uphill conveyor where they are delivered into the pickling aisle.

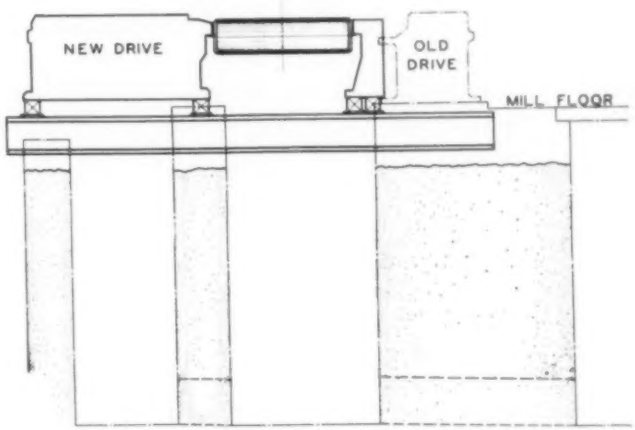


Figure 10 — Cross section through table.

The holding table between the roughers and the finishers was installed in a most congested area. The original mill with the furnaces delivering at right angles to the mill was arranged with two turnover tables. The slab was received on the approach table through the roughing scalebreaker and then turned over to go through the roughers. It was then again turned over toward the original direction to line up with the finishers. By making the mill a straight-away, it was possible to install the foundations (Figure 10) through the present roughing mill during normal shutdowns and still keep the mill operating. To do this a table cross section of a girder type was designed so that beams could be placed in the foundation and the new table welded to the top of the beams. This proved a quick method of installation and this plan was carried out on all tables installed with the exception of the runout tables which were designed to meet existing foundation bolts.

Scale handling was also given considerable attention. We decided to pick up the scale from the finishing scalebreaker into a collecting system which was designed for

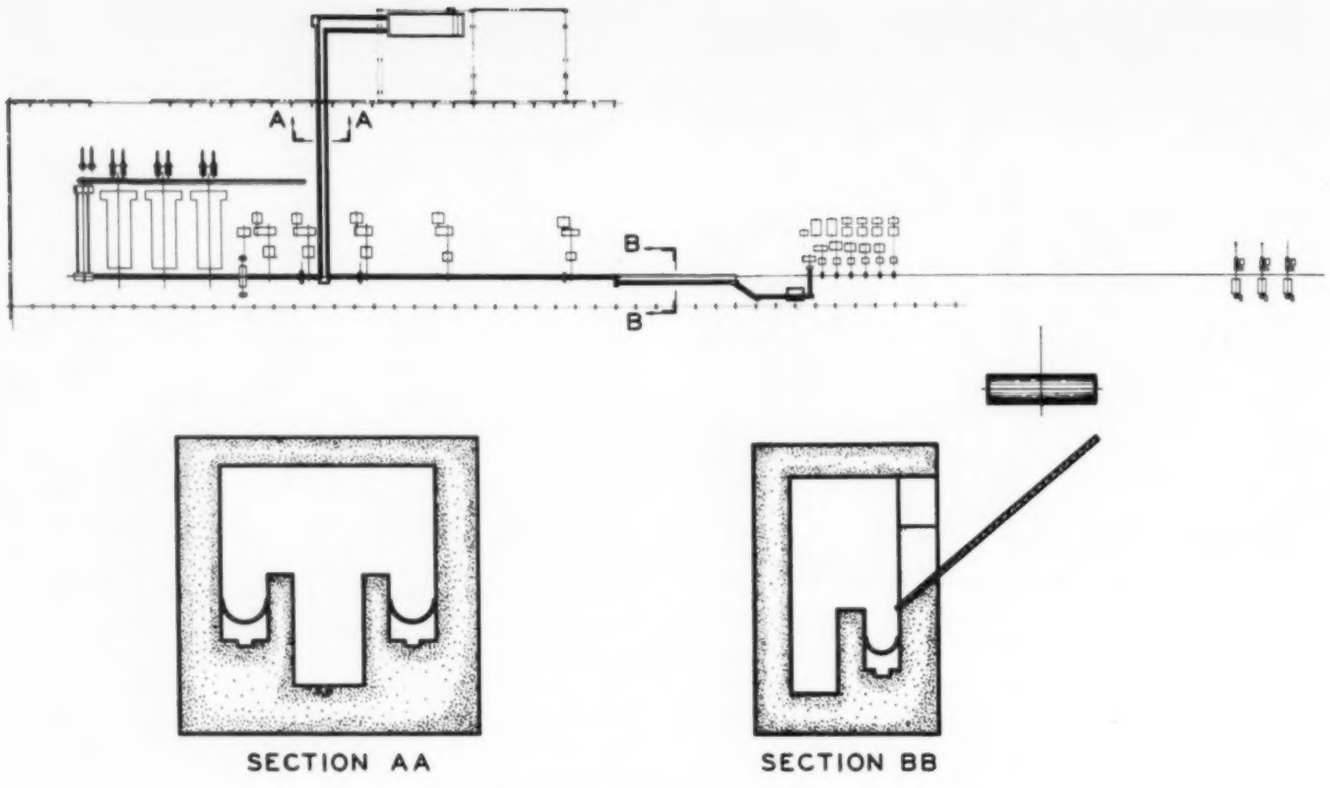


Figure 11 — Section shows design of scale handling system.

the new roughing stands, and since we could not install the sluice way in a proper location under the table between the rougher and the finisher, we picked it up outside and brought it to a point where we could get it under the table (Figure 11). Elevations of existing equipment were quite a problem and again this installation was done in steps. The system for scale is in a flushed chute with provision for maintenance as shown on these cross sections. Water is supplied from two 10,000-gpm pumps—one of which is a standby—and draws the water from a sump which is in turn fed by the furnace cooling water. The scale is gathered to a central pit located at the far end of the old original slab yard where the existing crane was utilized to dip scale from the collecting pit into cars. This pit is so designed to give a holding time of about ½ hr and also collect oil and grease by a system of weirs. The oil is collected in a heated trough and removed by pumping. Notice that two chutes are provided in the crossover, one chute carrying scale from the furnaces and the other chute carrying scale from the mill. This system has proven very satisfactory to date.

On August 17, 1955, the vertical edger and the four stands of the roughing mill went into operation and demolition of the existing roughing mills was begun.

Figure 12 — Roughing table features smooth top and sides.

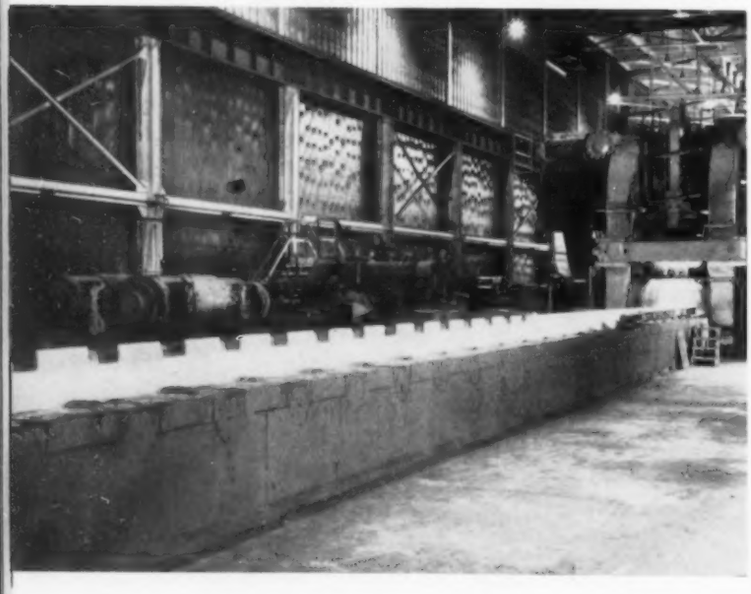


TABLE I

Type	Stand	Roll diam, in. (All 54 in. long)	Hp	Motor rpm	Gear ratio to one	Fpm
...	VE	42	1500	196	9.6	225
2-High	R1	44	4000	450	23.267	223
2-High	R2	44	4000	450	17.239	300
2-High	R3	44	6000	450	11.546	450
4-High	R4	35 WR 49 BU	6000	450	8.33	495
4-High	R5	35 WR 49 BU	6000	450	7.08	584
2-High	FSB	23¼	500	160/525	7.96	123/403
4-High	F6	26 WR 49 BU	2-2000	200/400	5.24	260/510
4-High	F7	26 WR 49 BU	2-2500	200/400	3.39	400/790
4-High	F8	26 WR 49 BU	1-3500 1-2000	175/350	2	595/1195
4-High	F9	26 WR 49 BU	1-3500 1-2000	175/350	1.486	800/1610
4-High	F10	26 WR 49 BU	1-3500 1-2000	175/350	1.19	1000/2000
4-High	F11	26 WR 49 BU	1-3500 1-2000	175/350	Direct	1169/2400

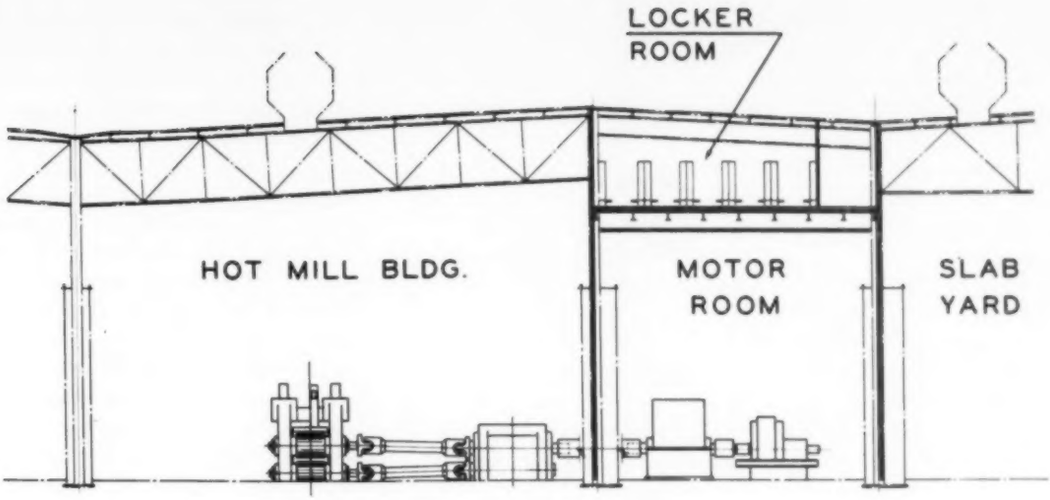


Figure 13 — A locker room was built over the motor room.

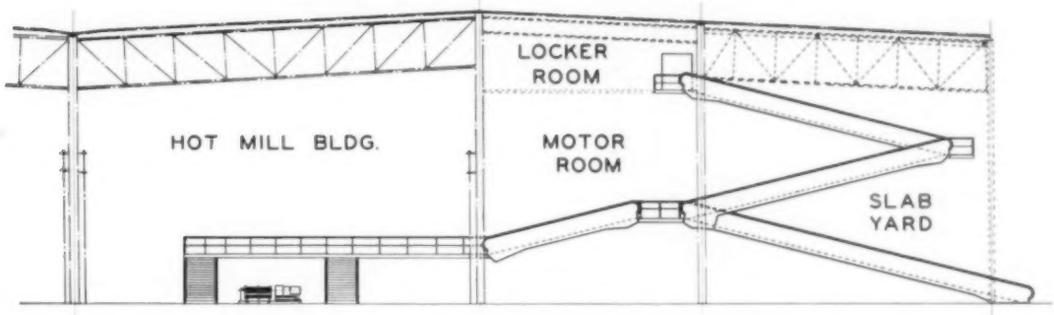


Figure 14 — Section shows escalator to locker room.

The location of the fifth rougher was in the vicinity of the original furnaces and could not be installed until the old furnaces were demolished. Since we had previously operated with four roughers, we again scheduled the mill on the same basis and the new roughers went into operation. When the furnace was demolished, the new foundation was installed and the fifth rougher was completed and put into service on January 9, 1956. Large slabs were then standard on the mill. The addition of the fifth rougher resulted in renumbering of the finishing mill stands and our No. F10 became No. F11 and so on back through the mill.

Of interest is the design of the roughing tables (Figure 12) which are made with smooth tops and sides on the drive and operator's sides. This design was selected from both appearance and maintenance standpoints since it is relatively easy to keep clean.

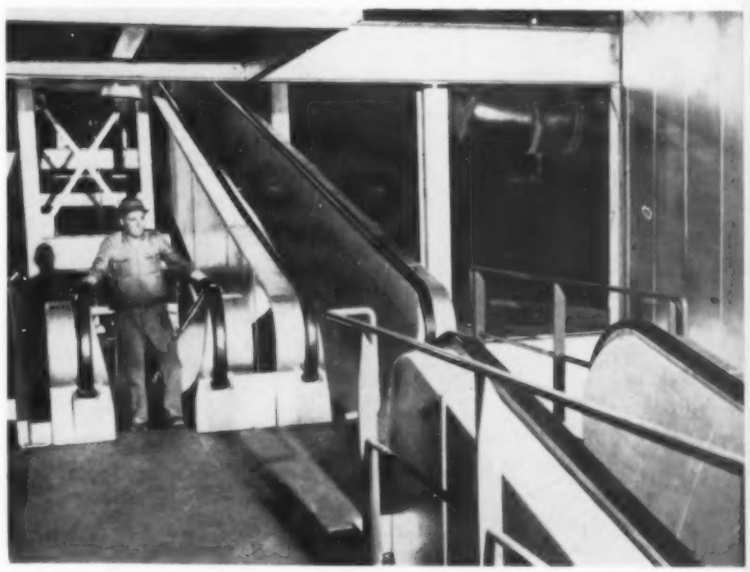
Selection of sizes for the roughing train will permit the use of backup rolls as follows: the backup rolls in the finisher and four high roughers are worn down to 44-in. diam., then they can be reused as work rolls in the three two-high roughers where they will scrap at about 33-in. When the rolls have been scrapped, the size is such that with a bit of machining they can be used as arbors for sleeved rolls to be reused in the finishers. Oil flooded backup bearings were also selected in size so that the same bearing could be used in all stands. Due to work roll sizes, the backup chocks are not interchangeable between finishers and roughers. See Table I.

Areas between the roughing stands from the substation to the mill are utilized as storage basements. This space was gained by adding only a floor and ceiling, the walls being the mill equipment foundations.

The new mill has a total main drive capacity of 59,000 hp. The a-c main drive horsepower is 27,500 composed of a 1500-hp wound rotor induction motor on the vertical edger and 26,000 hp of synchronous motors for the balance of the roughers. The total d-c connected horsepower is 38,100 which includes main and auxiliary d-c drives. The main drive motors are each provided with a blower and 509,000 cfm of air is recirculated through these motors. Another system furnishes 140,000 cfm of cleaned air to the recirculating blowers. Each motor is also equipped with an electric cooling unit in the air stream just under the motor.

Of general interest is the new central locker room (Figure 13) which was installed. We selected the top of

Figure 15 — Belt walks have a 14 degree slope.



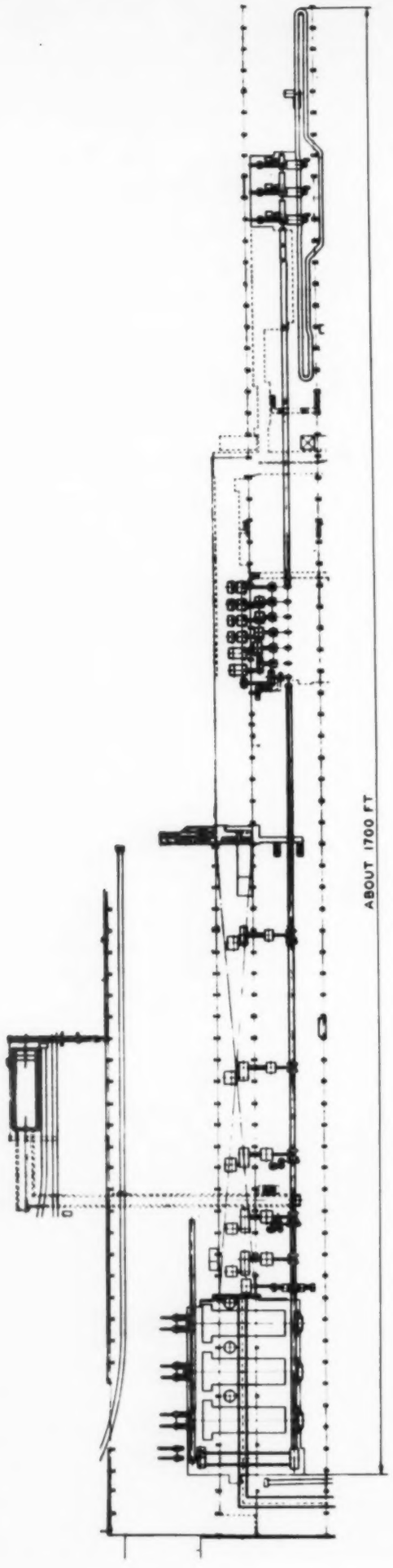


Figure 16 — Present mill layout extends above 1700 ft.

the motor room as locker room. This locker room is designed for 1700 men and centralizes all lockers, showers and toilet facilities. To maintain access, two waiting rooms are erected on Main Street with stairways to the locker elevation. At the platform end of the bridge over Main Street, the police office, paymaster's office, and dispensary are located together with the clock office. This arranges these facilities into an easily maintained unit. Since the height from the street to the locker room is 25 ft and the height from the mill floor to the locker room is 41 ft, it was decided to install some means of power elevating at the mill end of the locker room (Figure 14) so that the men coming from work could be transported to the locker room, and stairways were erected on the street elevation to get the men coming to work to the locker room.

Accordingly, an elevating system made from moving belts was designed. See Figure 15. The belts are on a 14 degree slope with a moving handrail and a general design similar to the elevating equipment found in more modern office buildings but not quite as elaborately dressed. In place of polished metal, we used $\frac{1}{8}$-in. hot rolled plate, and we still have a very attractive unit. In addition, stairways are also provided.

Water on hot mills has always been a problem and each stand of the mill is piped for 30, 80, and 125-psi pressures. In addition, 250 psi water has been installed on the roughing train and on No. F6, No. F7, and No. F8 only. The operators have full flexibility to select the pressure of water they require on each stand.

The mill has been equipped with X-ray width and thickness gages and television cameras. The cameras are located at the top of the slope of each furnace with one receiver on the operating table in front of No. 2 furnace. The other camera is located on top of No. 5 roughing stand pointing towards the finishing train. Receivers are located in the roughing pulpit and furnace delivery table pulpit.

The mill as completed from the slab reject table to the end of the coil cooling conveyor is 1700 ft overall. See Figure 16.

DISCUSSION

PRESENTED BY

M. A. JONES, Plant Engineer, Kaiser Steel Corp., Fontana, Calif.

L. A. FUGASSI, Assistant Chief Engineer, Weirton Steel Co., Weirton, West Va.

J. E. PEEBLES, Steel Mill Application Engineer, General Electric Co., Schenectady, N. Y.

R. F. EDWARDS, Section Engineer, Elliott Co., Ridgeway, Pa.

M. A. Jones: I think we can all agree that Weirton Steel has faced a real problem in the expansion of their hot strip mill. Evidence that they have done an excellent job of planning is that the mill was only out of production for a period of 15½ days.

We recognize the problem of relocating mechanical equipment, but we feel that one of the most serious problems is the relocation of electrical equipment. I would like to ask Mr. Fugassi what portion of the

electrical equipment was relocated, and what portion of the electrical equipment was new to allow its installation and setup prior to the time of the mill shutdown? Were the control panels and conduits installed ahead of the shutdown, or was all equipment rewired during the shutdown?

Were any problems encountered due to field changes on the relocated electrical equipment, and how seriously did they affect the shutdown time?

It is generally agreed among mill construction people that the best method of relocating mill equipment is set and aline the electric mill drive to the mill equipment. This usually results in extended shutdown time. I should like to ask Mr. Fugassi whether this was the case on the Weirton job or whether they deviated from this procedure in the interest of reducing mill relocation downtime, and if so, how this was accomplished.

L. A. Fugassi: The problem of relocating the electrical equipment, while difficult, was not as bad as it sounded. When we installed the 66-in. mill, the location of the slab finisher was considerably beyond the location of the old finisher, because we had a very short runout table on the old mill. The new equipment was installed beyond the old reel, so we had a fairly clear field there. We had all our electric conduits wired and new panel boards installed, for the new drive prior to the 16-day shutdown.

On your second question, as to the lining up of the mill, that was done during the 16 days in normal procedure of lining up. When we shut down, everything was ready for our construction people to begin work.

J. E. Peebles: Mr. Fugassi's fine paper describes the physical changes made in the hot strip mill at Weirton Steel while maintaining a high degree of production, a feat of which Weirton Steel Co. can be justly proud. A few of the electrical problems may be of interest.

It has been seen that each finishing stand now has a double armature motor. Each stand obtains power from a generator and a rectifier paralleled in an individual power supply. The control for this mill is required to be versatile enough so that the mill can operate with either the generator, the rectifier, or both the generator and rectifier supplying the motors. With any combination of conversion equipment, and within the load ratings of the machines, the terminal voltage at the motors must not drop more than 0.25 per cent from no load to full load. A small amount of IR compensation is desirable to improve the stand speed regulation. Effective load balance must be provided between the generator and rectifier when operating in parallel. Also, the rectifier should take the peak loads when paralleled with the generator because of the former's large size and inherent ability to handle heavy transient overloads.

The entire voltage regulating system was set up on an electronic computer and checked under various conditions. The results of this study showed that either singly or in parallel, the regulators meet the requirement of 0.25 per cent voltage regulation. Some IR compensation is necessary to keep the speed regulation to a minimum. The impact speed drop occurs immediately following a sudden application of load such as that of the strip entering a stand, in spite of anything the regulator can do. However, the study showed the regulator will cause the speed to recover in approximately 0.3 sec after such impact loading. The load balance was effective at as high as 200 per cent of rated motor current. The rectifier will take the peak current under transient conditions. Actual test curves made on the brush recorder after the equipment was placed in service show very close agreement with the computer study.

During rectifier arc backs, short circuit currents will be contributed by the motors and generator until the anode breaker opens. A short circuit study was made on the d-c transient analyzer to determine the protection necessary for the rotating machines. It was found that both motor and generator could carry the current peaks without being removed from service. Special attention was paid to the question of whether the generator breakers would trip before the anode breakers could remove the fault. If any line circuit breakers were to trip, the whole stand would probably be lost causing a cobble in the mill.

It is interesting to note the use which has been made of analytical equipment in the engineering of this mill drive system. It has been noted above that use has been made of the d-c transient analyzer and the Reeves electronic computer. The a-c network analyzer was used to check the a-c power distribution circuit breaker ratings and system load distribution. In addition, a behind-the-scenes use was made of the IBM digital computer in determining the constants of the various machines involved in the other studies. The problems of a complicated arrangement of machines such as is being used in the Weirton hot strip mill would indeed be difficult to cope with without the use of such analytical equipment.

Our companies' order included preparation of the main motor room layout along with foundation outlines for the installation of all main drive motors in the motor room. Our construction engineering people studied hundreds of drawings dating as far back as the original installation in 1927. Many of these old drawings are partially or totally void due to subsequent changes. To sift the valid information from the obsolete and prepare up-to-date drawings, many field measurements and inspections were made. This work was very valuable in assuring over-all co-ordination in the area involved.

In the modernization of this mill a real challenge was presented to all concerned to see how little interruption could be made in the production schedule. This challenge has been met.

R. F. Edwards: The change-over of the mill this way involves major hazards in getting electrical equipment installed without potential breakdown. I would like to hear Mr. Fugassi tell us what steps they took to keep their electrical windings dry and clean and free from mechanical damage. The repair of electrical windings in the event of damage—particularly, high-voltage a-c coils—could cause a major extension of shutdown time. Apparently precautions were taken to prevent that, and I am just wondering what sort of handling measures were taken.

L. A. Fugassi: We did nothing unusual nor took any special steps. Our construction people proceeded with the same care and watchfulness they apply to any major job and damage was not any more than that normally expected in such installations.

EXPERIMENTAL

By

W. E. SCHWABE

Product and Process Development Laboratory

National Carbon Co.

Niagara Falls, N. Y.

▲ THE electric arc in a steel furnace is a heat source of a power concentration unknown in any other conventional thermal process; for example, an arc of 8000-kw power in a modern large size furnace occupies a space of 15 to 25 cu in., corresponding to an average energy density of 300 to 500 kw per cu in.

The electric furnace arc is a gaseous discharge, the physics of which are not fully understood. Experimental work at commercial arc furnaces is limited by practical considerations, since they are costly tools of production and do not permit the variation of conditions desirable from a research point of view. Similar arc phenomena, such as illuminating and welding arcs, have been subjected to theoretical and experimental investigations during the last five or six decades, but due to their much smaller magnitude, results of these works cannot be easily applied to furnace arcs.

Several years ago our company initiated a research program on electric furnace arcs combining laboratory experimentation at a small furnace with field tests at commercial furnaces of various sizes. The objective was to study the electric furnace arc, the conditions for its erratic behavior during meltdown, and, if possible, to improve arc steadiness so as to deliver a more uniform and higher average power, and to reduce disturbances in power networks. Although much remains to be done, sufficient progress has been made in this field to warrant a report.

ARC STABILITY AND ARC STEADINESS

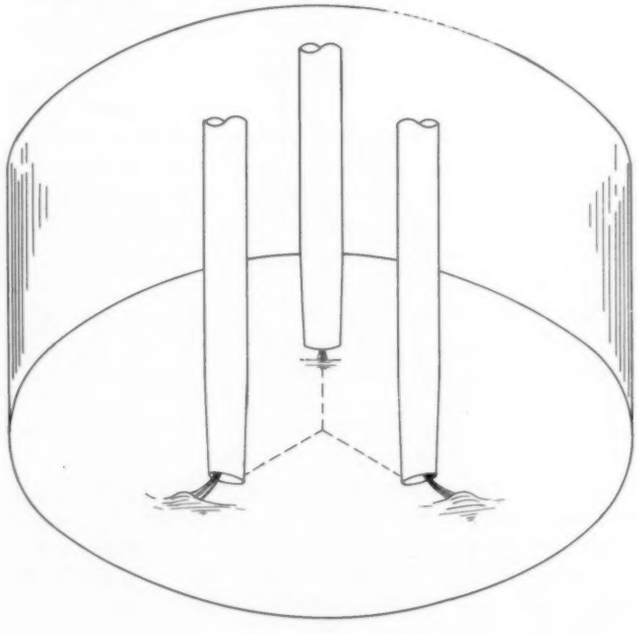
It is well known that an electric arc is a nonlineal electric resistance requiring a ballast in the circuit to limit the current. In large steel furnace installations, the inherent reactance of the high-current bus system and flexibles supplies the required reactance, whereas smaller furnaces have to be equipped with supplement reactors. Ballast impedance and the volt-ampere characteristic of the arc for a given, constant arc length determine electrical stability of the arc, a criterion established during the early days of arc research. However, in designing electric furnace power supplies, one is limited in the choice of ballast and arc resistance for economical reasons such as investment, power factor and safety. Transformer size for a given furnace capacity, as well as tap voltage and operating current, have been pretty well established by experience.

According to the above definition, the arc in a commercial furnace is a stable arc, but contrary to an illuminating arc, the arc length is subjected to rapid changes. Furthermore, the electric conductivity of the arc undergoes sudden changes caused by variations of the ionization by chemicals, such as impurities, slags, etc., entering the arc zone by random. These variations combined cause the furnace arc to be unsteady, although it operates almost exclusively in the range of electrical stability. Erratic conditions of the arc, therefore, have to be treated as a problem of arc steadiness.

FACTORS GOVERNING ARC STEADINESS

Arc steadiness may be defined as the ability of the arc to maintain a constant electrical resistance. The arc, being a gaseous and, consequently, rather flexible conductor, may be compared with a short length of heating wire of a fairly large cross-section. The resistance of a conventional conductor, such as this heating wire, is proportional to its length and its specific resistance and inversely proportional to its cross-section. Suppose we could deform the geometry of this heating wire by rapid expansion and contraction and also change its specific resistance by changing its metallurgical composition, we would notice rapid changes of the current in accordance with the instantaneous values of the resistance. This analogy, although somewhat oversimplified, describes the phenomena occurring in the furnace arc: variations of the arc length and its cross-section are initiated by turbulence of the melt and other factors to be discussed later, the specific resistance undergoing variations caused by rapid changes of ionization conditions.

Figure 1 — Arc flare in a 3-phase steel furnace is forced to outside.



RESULTS WITH HOLLOW ELECTRODES

in Electric Steel Furnaces

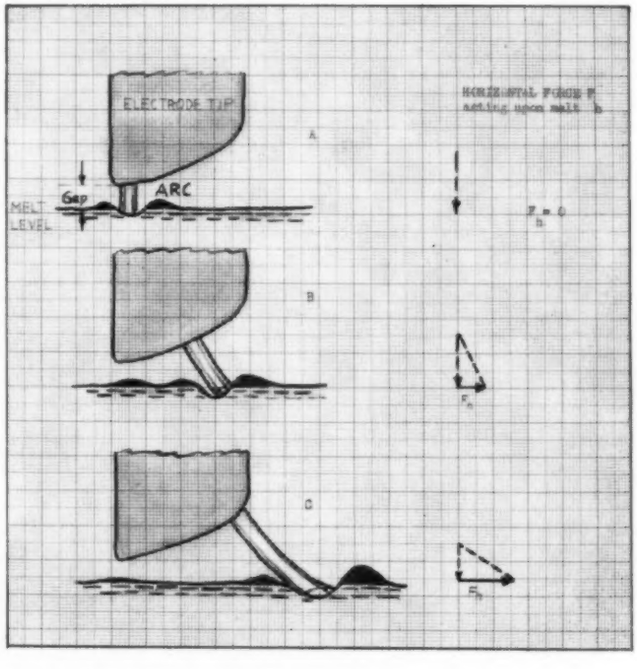
. . . . experiments indicate that hollow electrodes will give a steadier arc, faster melting and lower power requirements . . . . on the other hand it appears that this occurs at a higher electrode consumption rate . . . .

Variations of length and conductivity may occur simultaneously. There combined effect is reflected in the magnitude of the current. Arc length variations can be occasionally observed visually or recorded by motion picture photography, whereas the variations of the specific arc resistance can only be detected by analysis of electrical quantities.

PHYSICAL CONDITIONS CAUSING CHANGES OF ARC LENGTH

Our experiments in conjunction with theoretical studies proved that mechanical forces acting upon the arc and within the arc are responsible for dislocations of the arc. External forces can be explained by the existing structure of the magnetic field established by the arc and adjacent conductors. In a three-phase furnace, two electrodes in conjunction with the two arcs and the conducting melt between, form a loop. According to Maxwell's theory, a loop condition has the inherent tendency to increase its self-inductance and, consequently, its area. Since the electrodes are inflexible and the melt is rather heavy, the arcs are forced toward the outside as shown in Figure 1. Due to the influence of the third electrode and the current of this phase, all three arcs are forced in the direction of the radius toward the side wall. This effect is called arc flare and, in a similar way, is also encountered in arc welding. It can be observed during meltdown that the arcs cause the electrode tips to be levelled at angles between 20 and 30 degrees, the reason being that the hot spot on the electrode prefers the outer part of the tip. Consequently, this part of the electrode is consumed faster. Arc flare is a force acting in horizontal direction toward the shell, its intensity per unit arc length being approximately proportional to the square of the current.

Figure 2 — Arc condition contributes to quasi-cyclic current fluctuations.



As mentioned above, there is another mechanical force within the arc acting in the direction of the arc axis. The nature of this force is not fully understood. It causes a depression in the melt, and its magnitude depends on the current.

The interaction of these two forces is illustrated in Figure 2. Figure 2A illustrates an initial arc under the electrode. The gap "G" is small and, therefore, the current is high, and the corresponding power factor is low. A vertical force acts in the direction of the arc causing a depression in the melt. Due to the magnetic influence of the two adjacent electrodes in connection with the magnetic field surrounding the current paths in the melt, a horizontal force F_H is exercised upon the arc tending to displace it toward the shell.

Figure 2B shows the arc in a new position. A very important phenomenon can be seen on this figure, namely, that the axis of the arc stream in the vicinity of the electrode tip forms a right angle with the surface of the electrode. The axis of the arc is no longer a straight line. Since it also displays an angle with reference to the vertical, the arc force now has a horizontal component

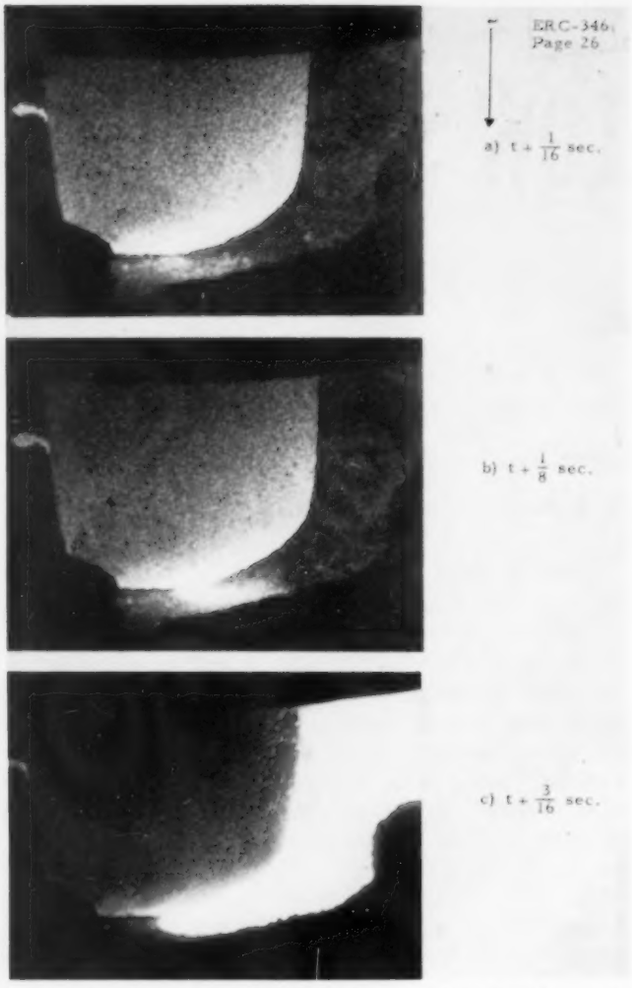


Figure 3 — Sequence of movie frames show ignition of a furnace arc (14-in. diam electrode); a. prior to ignition, b. initial arc, c. full arc of 16,000 amp forced toward furnace shell by magnetic forces.

F_H pushing the melt in the direction toward the furnace shell. Once a floating hot spot on the melt has been established, it is easy for the arc to jump into the extreme position (illustrated in Figure 2C) with a very pronounced downward bow and a considerably increased horizontal force component F_H. If the hot spot on the melt offers an arc supporting effect by improved thermo-ionization (such as floating slag or impurities do) the arc has the tendency to remain on this spot until the particles have been forced far enough so that the arc no longer can exist.

Shortly before the arc is subjected to extinction, a new arc has started at the heel of the electrode as shown in Figure 2A, either by electrical breakdown or by physical contact of a wave crest with the electrode, depending on the gap and the degree of turbulence of the melt. Thus we have a more or less cyclic variation of the effective arc length due to the external and internal forces.

In addition to this effect, it has been observed that the arc in a fixed position of Figure 2C changes its length due to waves on the surface of the melt.

Furthermore, in the extreme position, rectification or partial rectification of the current can take place reducing the effective value of the current considerably during short time intervals.

It can be seen from Figure 2 that a slight dislocation of the arc is associated with a considerable change of its length and, consequently, its electrical resistance. Changes of arc length occur rapidly; high speed motion pictures showed that in extreme cases the cyclic process took place several times during one-half cycle of the current. An average rate of occurrence is two to eight per second. One governing factor is the reluctance of the hot spot to move on the surface of the melt. In all probability, viscosity of melt and slag, as well as thermal inertia, play an important part.

Figure 3 shows three consecutive frames of a motion picture taken of the arc in a production furnace using 14-in. diam electrodes. Figure 3A shows the electrode tip and the melt. The arc was extinguished due to the extensive arc flare. On Figure 3B, 1/16 of a second later, a new and very short arc is initiated, probably by electrical breakdown between the hottest spot on the electrode and the melt. After another time interval of 1/16 of a second (Figure 3C) the initial arc has developed into a full size arc being forced in the direction of the upper right corner of the picture. In this case the arc can hardly be distinguished from the flame initiated by the arc spot on the melt.

Figure 4 is a reconstruction of a movie frame showing the arc in two positions during the exposure of 1/30 second. Note that a considerable part of the outer arc

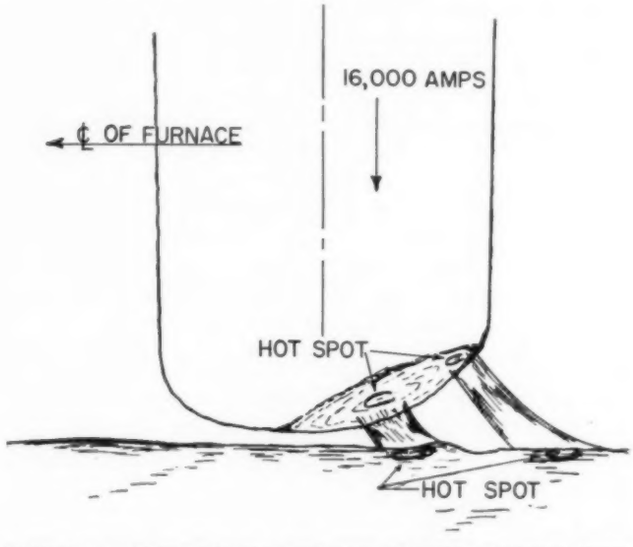


Figure 4 — Electrode tip and arcs as reconstructed from movie frames (14-in. diam electrode with 16,000 amp).

occupies a space outside the area projected from the electrode tip on the melt surface. Thus, the arc striking at a rather flat angle radiates a part of its energy toward the roof and the upper part of the sidewalls, a condition undesirable at the end of the meltdown, possibly causing wear on the refractory.

On several occasions it could be observed that, when the arc flashes to the outside, a flame originates from the hot spot on the melt and extends in the direction of the sidewall.

This is illustrated in Figure 5 showing a movie frame of an arc in a single phase experimental furnace. Obviously, this flame is a highly potent source of radiant heat, and must be partly absorbed by the refractory.

In addition to external and internal dynamic effects,

Figure 5 — Arc in an extreme position shows flame emanating from melt.

forces due to gas, vapor and air convection are present in the arcing zone. It seems almost impossible to postulate their influence upon arc steadiness in quantitative terms.

Another influence governing arc steadiness is given by sudden changes of the electrical conductivity in the arc zone due to explosion-like vaporization of metal or arc supporting materials. At a given arc length, the electrical conductivity may be improved up to 50 per cent, and falling back to its original value almost instantaneously after the arc supporting material has been consumed.

Thus, there is a variety of physical and chemical effects influencing arc steadiness, and their combined effect, in connection with the electric power circuit, determines the magnitude of current and power.

RELATIONSHIP BETWEEN ARC STEADINESS AND POWER RELEASED IN THE ARC

For a given tap voltage, the relations between the arc current and all other electrical quantities are presented in the so-called furnace characteristic.

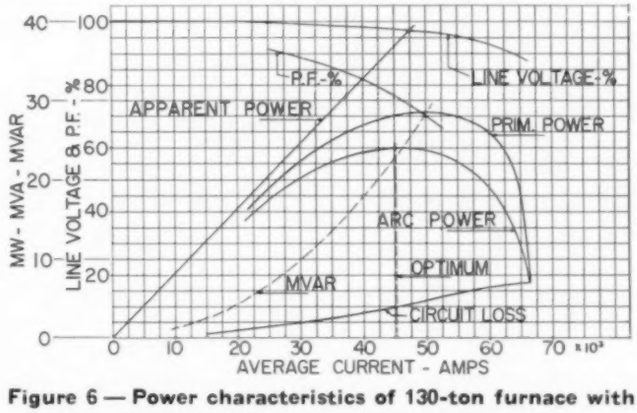


Figure 6 — Power characteristics of 130-ton furnace with 24-in. diam electrode, 475 volts phase-to-phase.

Figure 6 is a diagram illustrating these conditions for a 130-ton furnace. The values are based on actual experiments and are well in line with general theoretical derivations as presented in the literature. On this diagram, the total or primary power (kw), the useful arc power (kw) as well as line voltage and power factor are plotted vs arc current. It becomes evident that in order to obtain maximum arc power it is necessary to maintain a certain current, the so-called electrical optimum current. Theoretical and practical discussions concerning the determination of this current are offered in the literature.

There is some indication that this electrical optimum current is not necessarily the most efficient operating current, but it is generally agreed that from the standpoint of power economy this current should not be exceeded.

Therefore, if this current could be maintained absolutely constant during meltdown of a heat, we would have the ideal condition of highest power in the arc at a uniform rate. We know that conditions in the arc, especially during meltdown, are far from this ideal.

Due to the rapid and erratic changes above described, which cannot be balanced by a regulator instantaneously, the current deviates from its optimum value and causes a decrease of power during either period above and below the optimum value.

Positive and negative deviations do not necessarily occur simultaneously in all three phases, but are cancelled to a certain degree. Nevertheless, the rate of useful power is reduced by these current fluctuations. It should be stressed that on Figure 6 an average current value of all three phases is used as the "X" co-ordinate. Actually the currents in the three phases are not symmetrical due to the difference of the mutual inductance between the three phases in the high current conductor system. This phenomenon is known as the "dead" and the "hot" phase. We have studied this problem in detail and will present a discussion on this subject at a later date.

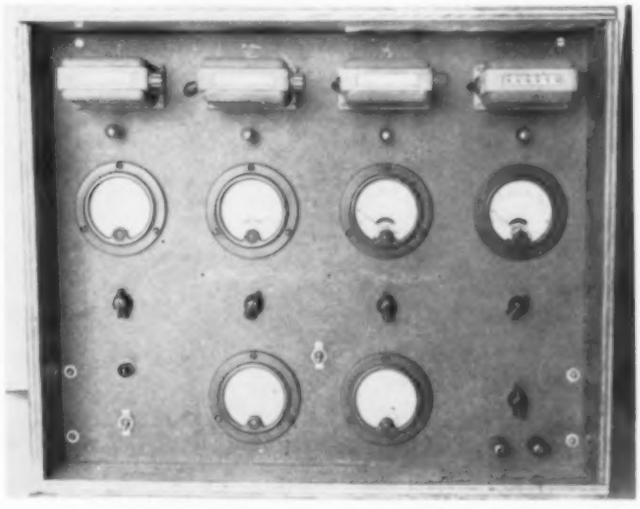
ARC PERFORMANCE FACTOR

From a standpoint of economy and maximum heating rate, we are interested in having an arc as steady as possible operating at the rate of the optimum current.

In order to establish a quality mark for the behavior of the arc, we propose the term *APF* factor. This is a percentage ratio and defined as the quotient between the actually measured useful arc kw hr to the maximal obtainable kw hr according to the furnace characteristic during a given time period. In the case of the ideal steady arc previously mentioned, the *APF* is 100 per cent.

At several production furnaces, we found that the arc performance factor during meltdown reaches an

Figure 7 — Load swing analyzer was developed for studies.



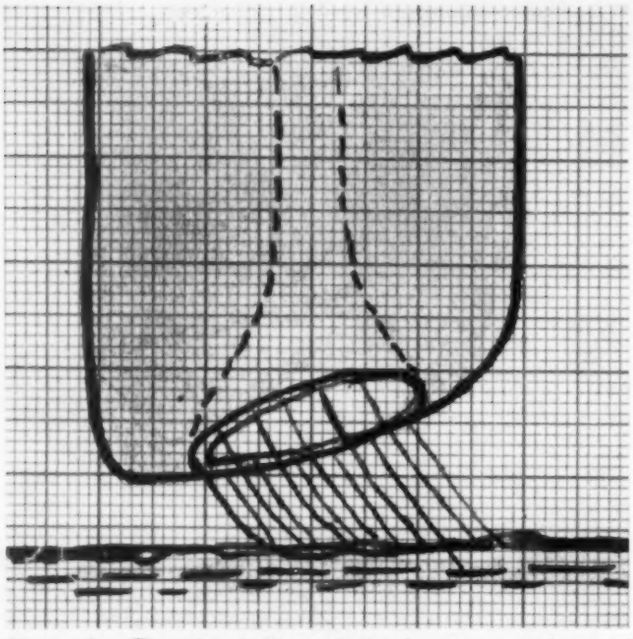


Figure 8 — Tip of a hollow electrode assumes shape of funnel.

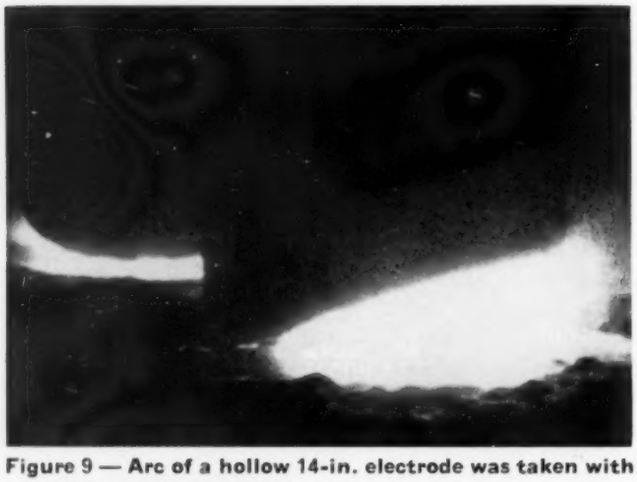
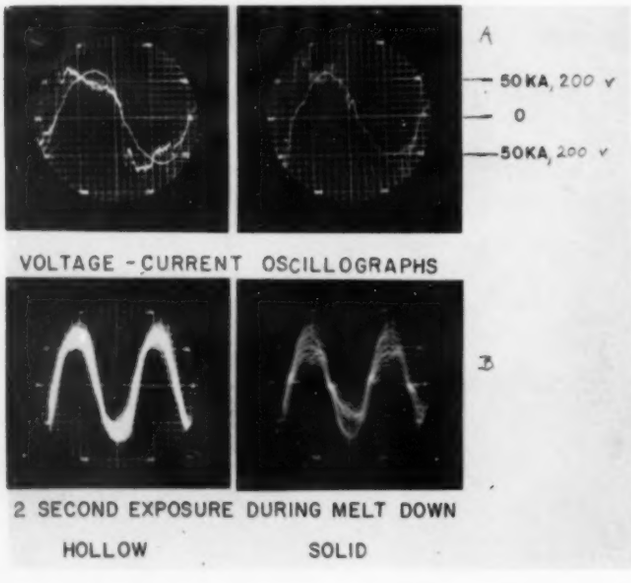


Figure 9 — Arc of a hollow 14-in. electrode was taken with high speed photography.

Figure 10 — Arc current and voltages of solid and hollow 24-in. electrodes during meltdown, given in A, and B, are 2-sec time exposures of current waves, in hollow and solid electrodes during meltdown.



average of 83 to 85 per cent. As will be shown later, it is lower during the first 15 minutes of melt down when numerous short circuits occur due to physical contact between scrap and electrodes.

ANALYSIS OF LOAD SWINGS

Arc steadiness may also be expressed by the number and magnitude of current swings occurring during furnace operation. According to the power characteristic, current swings approaching the range of the short circuit current not only decrease the useful power rate, but also the average power factor. Such swings are undesirable because they create mechanical forces between the transformer windings and, under certain conditions, may cause line voltage fluctuations and lighting flicker in power networks.

In order to investigate current swings, we carried out experiments using string oscillographs, cathode ray oscilloscopes and high speed recorders. Evaluation of these records, although revealing minute details occurring in current, voltage and power during short time intervals, is extremely tedious and time consuming. To overcome this difficulty, we developed an electronic instrument which consists of several electromagnetic counters capable of counting the number of deviations of the current from its optimum value within four ranges up to 16 times per second. This load swing analyzer is shown in Figure 7. It proved to be more convenient than the above-mentioned instruments since it can be operated during any desired period of time, giving direct results and facilitating long term tests.

This instrument permits the detection of current

Figure 11 — Arc performance factors of hollow and solid electrodes during meltdown (14-in. electrodes) show better efficiency of hollow units.

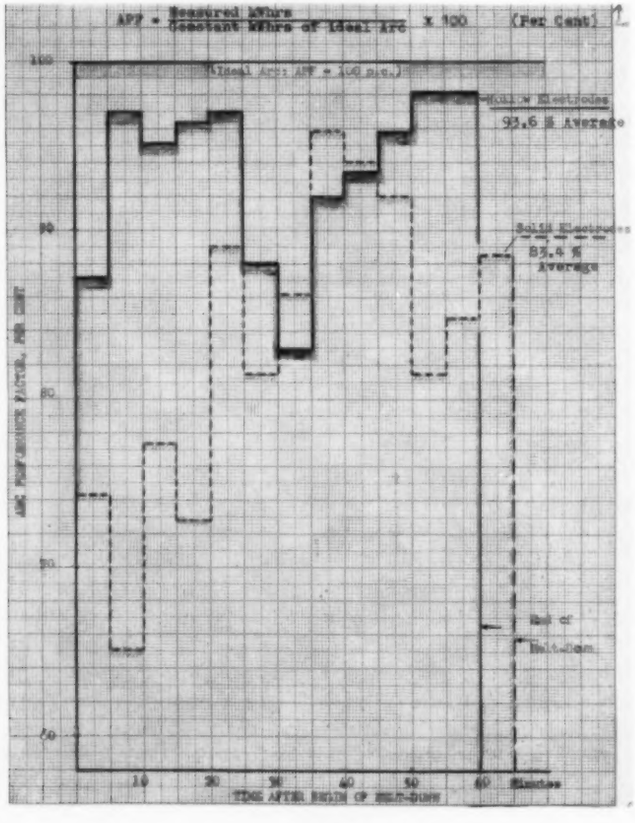


TABLE I

Comparison of Load Swings Caused by Hollow and Solid Electrodes in Steel Furnaces During Meltdown

Furnace capacity, tons	Meltdown, MW	Power factor, per cent	Tap voltage, phase/phase	Arc current x 1000 amp	(Averaged Data) Number of short-circuit surges per minute		Reduction factor K	Per cent short circuit surges eliminated by hollow electrodes
					Solid electrodes	Hollow electrodes		
15	5.5	79	234	16	10.9	3.5	3.1	68
70	19	79	355	35	16.4	6.3	2.6	61.5
130	25	77	475	45.5	7.4	3.5	2.1	52.7
								Average 60.8

swings of small magnitude within the range of optimum current, but we found that the behavior of the arc is sufficiently described by the average number of short circuit current swings per minute during meltdown.

EXPERIMENTAL RESULTS WITH CONVENTIONAL AND SPECIAL ELECTRODES

At an early stage of our experimental work, we noticed that arc steadiness can be remarkably influenced by the geometry of the electrode tip. Electrodes providing a concave tip were found to reduce arc flare considerably by focusing the arc under the electrode tip, thus reducing the magnitude of changes of the arc length. The desired geometry of the tip can be readily obtained during furnace operation by using hollow electrodes.

1. Arc condition at a hollow electrode tip—A cross-section of the tip of a hollow electrode is shown in Figure 8. Consumption on the outer and inner surfaces establishes a steady state geometry of an inverted funnel. The arc has the tendency to ignite at the inner edge of the opening, especially from the part closest to the melt. One reason for this is the higher temperature assumed by the inner edge and the improved thermo-ionization. A certain minimum diameter of the funnel opening is required to prevent the arc from jumping to the outer part of the electrode as previously shown in Figure 2 for solid electrodes.

Furthermore, the arc of a hollow electrode appears to be diffused and less susceptible to magnetic forces. There is some indication that the arc of this type, at least during certain times, consists of a column rotating at high speed on the inner edge of the electrode tip thus giving the appearance of a diffused column. This arc does not have the pronounced bowed-down shape of the solid electrode as shown in Figure 5.

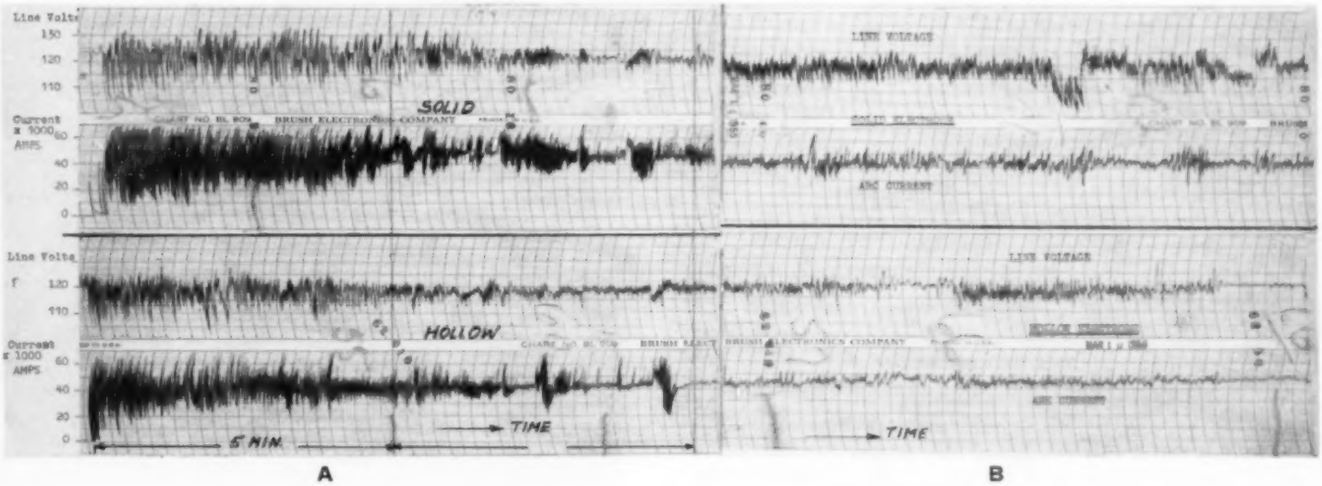
Side flashing is greatly reduced, and for given voltage and current conditions, and for identical length, the hollow electrode arc has a more vertical position, increasing the gap between the heel of the electrode and the melt. The turbulence of the melt appears to be less than with solid electrodes, and the motion of the melt on the surface is more uniform. Figure 9 shows the arc under a hollow electrode of 14-in. original diameter.

Note the concentration under the electrode in contrast to Figures 3, 4 and 5.

The hollow tip has an arc supporting effect, which is also reflected in a more sinusoidal shape of the current and in a less pronounced harmonic distortion of the arc voltage, shown on Figure 10A. For this reason the effect of the inductive circuit reactance is somewhat lower with hollow electrodes, resulting in a slightly increased power factor. Figure 10B is a two-second time exposure of the arc current and wave pattern. The band of the hollow electrode current is narrower indicating a steadier current flow.

2. Arc performance factor of hollow vs solid electrodes—Averaging the results of our tests at commercial arc furnaces we found that the arc performance factor during meltdown was 84 to 85 per cent for solid and 93 to 94 per cent for hollow electrodes of various diameters. These figures must be considered as approximations since they are influenced by numerous

Figure 12 — Arc current and line voltage records during meltdown are given in "A" during first ten minutes after "power on," and in "B" on right during 40th to 50th minute.



A B

variables such as scrap conditions, tap voltages, power program, etc.

It seems that the arc performance of hollow electrodes is better during the first 15 minutes after "power on," where most of the surges occur.

Figure 11 shows the *APF* determined in five minute time intervals during meltdown with 14-in. hollow and solid electrodes. Note that the hollow electrode performance during the first ten minutes climbs from 87 to 97 per cent, whereas the solid electrode *APF* is far below 80 per cent during the same period. Over the total meltdown period, the averages are 93.6 per cent for hollow and 83.4 per cent for solid electrodes in this case. The effect of steadier and higher rates of power and heat upon furnace performance will be discussed later.

3. Load swing analysis of hollow vs solid electrodes—Considering the short circuit surges during meltdown averaged in each case for a sufficient number of heats, we obtained the following result compiled in Table I attached. The readings were taken with the load swing analyzer. Note the hollow electrodes reduced the number of short circuit swings by a factor K ranging from 2.1 to 3.1. Individual heats may deviate considerably from the values presented in Table I.

Figure 12 shows the current of phase B of a 130-ton furnace registered with a high speed recorder during each heat with hollow and solid electrodes in conjunction with the line voltage recorded at the plant bus. Charts on Figure 12A were taken during the first ten minutes of each heat when arc conditions were most erratic. Figure 12B represents the time interval between 40th and 50th minute of the same heat. In both cases, hollow electrodes display a quieter operation and less disturbance of the line voltage.

4. Melting rates of hollow vs solid electrodes—It is well known that definite and reliable figures on production rates in steel furnaces require extended observations to average out all the variables and unknowns. Since our field tests covered only a limited period of time, and between 25 and 40 heats at each furnace, the following figures should be considered as indicative only.

We determined the hourly melting rate by relating the tonnage of the scrap to the "power on" or "active" time elapsed during meltdown excluding time used for oxygen operation and delay time. The results are shown in Table II:

TABLE II

Furnace capacity, tons	Meltdown rate electrodes, tons per hr		Per cent gain from hollow electrode, M
	Solid	Hollow	
15	14	16	15
70	45	49	10
130	50	53	5

In addition to a higher meltdown rate, energy consumption (kw hr per ton) during meltdown was found to be lower in some cases because of reduced heat losses of the furnace by a faster meltdown.

During refining there was no noticeable difference in power input between hollow and solid electrodes, since conditions for the arc such as ionization are by far better than during meltdown.

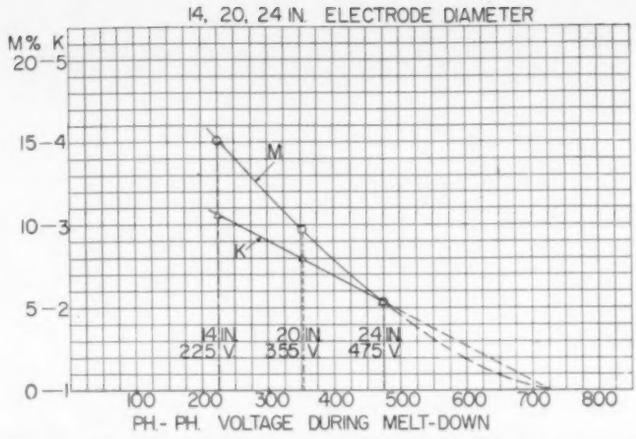


Figure 13 — Correlated results of hollow electrodes show per cent gain of melting rate (M) over solid electrodes and reduction factor K of short circuit surges plotted vs tap voltages of furnace.

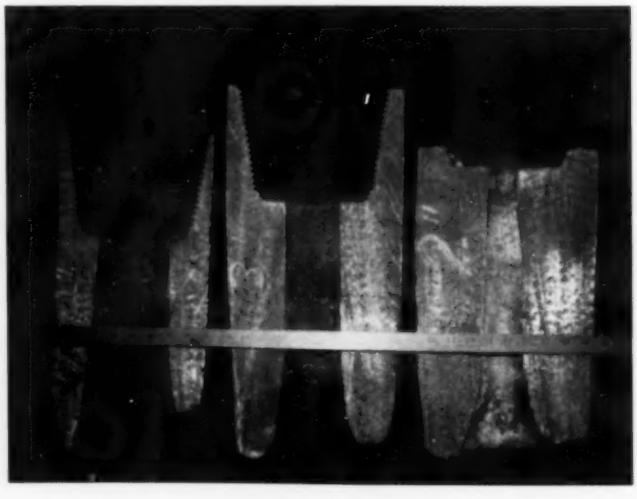
Since meltdown comprises only a fraction of the total time for a heat, over-all benefit resulting from hollow electrodes is a fraction of the values indicated on Table II, and would vary with changes in the ratio of meltdown to total time.

5. Correlation of results—Since the advantage of hollow electrodes stems from the specific structure of the arc, one governing factor is the arc length. Arc voltage for practical purposes is proportional to arc length, but it is a rather fictitious quantity as far as measurements are concerned. Since the furnaces during the test were operated near optimum conditions, the ratio between the active arc voltage and the transformer tap voltage is nearly constant. Therefore, the tap voltage under load can serve as a common denominator. In Figure 13 the following quantities taken from Table I and II are plotted vs tap voltage under load:

a. The factor K by which the average number of short circuit surges has been reduced by the use of hollow electrodes. The three points are located on a straight line, showing a steady decline with increasing tap voltage.

b. The per cent gain M of the melting rate due to hollow electrode operation. These three points in-

Figure 14 — Sections of hollow electrodes after testing. Original diameter was 14 in. Bore diameters were 4, 3 and 2 in.



dicate a more pronounced decline with increasing tap voltage.

Extending the K-line toward higher tap voltages shows that the advantage of hollow electrodes gradually vanishes and reaches zero at approximately 730 volts. The highest tap voltage used in a furnace at the present time is slightly above 500 volts, and the majority of steel furnaces operate in the range where both K and M are appreciable. The influence of the tap voltage is not surprising, because as previously explained, higher tap voltage means larger gap between electrode tip and melt and less chance of physical contacts.

6. Electrode consumption—The rate of consumption of hollow electrodes was found to be higher than for solid electrodes under identical furnace conditions. Limiting this additional consumption is a question of choosing the right bore diameter for the electrode. Too large bore diameters cause excessive additional consumption at the inner surfaces, but deliver the desired hollow electrode effect. Undersize bore diameters do the opposite. Therefore, a compromise as to the bore diameter has to be found. Figure 14 shows hollow electrode stubs removed from the furnace after the test. The original diameter was 14 in. and the bore diameters were 4, 3 and 2 in., respectively. All three electrodes gave the advantages of a hollow tip to practically the same degree, but the consumption rate of the sample on the right hand side was considerably lower than for the two other ones. The average rate of consumption in pounds graphite per ton output during our tests was between two and ten per cent above the rate for solid electrodes.

It is interesting to note that after meltdown the electrode tips display an angle vs the horizontal due to non-symmetrical consumption. During refining when lower voltages and currents are used and arc flare is reduced, the tips become more or less flat and the same cycle is repeated during the following heat.

Chimney effect within hollow electrodes greatly increases oxidation losses. During the tests, conventional nipples were used, which present an obstruction to the vertical draft.

7. Refractory life—The focusing effect of the hollow electrode tip upon the arc tends to reduce side flashing of the arc. This was established by visual observation during meltdown and refining. Therefore, it may be assumed that less heat is radiated upon the roof refractory. However, comparative investigations of refractory life require a long term test, and because our experiments comprised a limited period of time, we are unable to present definite results as to refractory life.

SUMMARY

Experimental data presented in this report are derived from laboratory tests followed up by trials at production furnaces in the field. Laboratory experimentation permits a systematical variation of parameters such as power and scrap conditions and, with respect to arc studies, the very important possibility of continuous visual observation of the arc. On the other hand, the physical size of the equipment is too small to justify extrapolation of results, by simply applying scale factors.

In contrast to this, production furnaces are operated in accordance with requirements which do not allow systematic investigations desirable for research and development.

For these reasons, work was limited in scope and should not be considered as a definite solution to the problem, but rather as one step in this direction.

It is typical for steel furnace operation that practically all the quantities and criteria involved undergo unpredictable variations. Melting rates, energy and electrode consumption, for example, are very much affected by scrap condition, refractory, tap-voltage and delay intervals and, as was previously pointed out, required long-term testing.

Since tests were limited, we had to use special instrumentation, but we are aware of the fact, that the results are more indicative than definite. Therefore, data presented in this report should be considered as such. Further trials are a necessity to clarify the picture, especially in view of a possible advantage of hollow electrodes with respect to refractory life, reduction of load surges and improvement of the power factor.

Improved steadiness of the furnace arc will benefit steel furnace economy, and facilitate the supply of electric power.

Hollow electrodes offer certain advantages during meltdown, such as a steadier arc, higher and more uniform level of useful power, but at a higher consumption rate, and consequently, at higher electrode costs per ton steel.

Since the relative value of each factor is different for each steel plant, each furnace, and also varies with demand for steel, no general statement can be made. It is up to each individual steel furnace operator to decide the over-all economy of operating with hollow or solid electrodes.

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DISCUSSION

PRESENTED BY

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W. E. SCHWABE, Product and Process Development Laboratory, National Carbon Co., Niagara Falls, N. Y.

C. W. VOKAC, Manager, Hydro-Arc Furnace Dept., Whiting Corp., Harvey, Ill.

WALTER PATTERSON, Melting Consultant, Allegheny Ludlum Steel Co., Brackenridge, Pa.

J. A. Brosovic: This paper and the ideas it conveys certainly indicate that we have much to learn about controlling the electric arcs in steel producing furnaces. The preliminary testing of hollow electrodes at Republic suggests that we may anticipate reduced kwhr per ingot ton and improved refractory life. Unfortunately, both benefits are yielded at the cost of

increased electrode consumption. The extent of the increased consumption of course is determined to some degree by the operating characteristics of each particular furnace. Visual observation has illustrated in one case, however, that increased consumption may be caused by (1) Increased severity of thermal cracking of electrode sections, and (2) Increased severity of butt losses.

In order to further classify and improve the operating characteristics, I would like to suggest that these items be given special attention during future tests, as well as to the frequency with which partial butt losses destroy the hollow electrode effect.

W. E. Schwabe: We noticed in two or three instances that we had splits of the electrode. Splits of electrodes occur every once in a while and they are really hard to predict. It is possible that because of mechanical handling of the electrodes these cracks may have occurred. At the present time, we drill holes into the electrodes, which require mechanical operations in the workshop.

On the other hand, it is hard to conceive that a hole of, say, 1-in. in a 20-in. electrode should affect the mechanical strength of the electrode. Theoretically, we should expect greater strength.

As far as butt losses are concerned, I think these are partially influenced by the taper of the electrode. This, in turn, is dependent on the current density, chimney effect and the oxidation rate; partly a factor of electrode material, also.

C. W. Vokac: I look upon the construction and geometry of an arc as being similar to the construction and geometry of a hollow weed. I see the arc as composed of so many electron paths, each carrying electrical energy like so many fibers in a hollow weed carry food energy to the top of the plant. I see the weed or arc getting fat or skinny, according to the amount of energy it must carry, but always hollow.

It is generally accepted that the arc current travels down the electrode also in a hollow circular pattern for the same reason—skin effect. It is logical, then, to remove material from the center of the electrode tip to create the tendency described in Mr. Schwabe's paper, if it is desired to prevent the hollow circular current in the electrode from crossing the center of the electrode before it passes from the electrode to the arc.

Certainly, the central void of a hollow electrode would increase the impedance of those current paths which are crowded against the central void to discourage further horizontal shift of the arc radially outward.

It should be pointed out, also, that the arc conductivity is changed by the amount of current in it. For instance, if more energy must be carried through the hollow weed or hollow arc, more fibers or paths are added naturally, and the weed or arc becomes fatter; the total conductance of the weed or arc becomes greater and, reciprocally, the total resistance of the weed or arc becomes less. Perhaps this analogue will convey a better concept of the arc character and structure.

It is significant, also that any change in the arc resistance, or impedance, however caused, can be controlled only by positioning the electrode—at least that is the only way it is done to date. The paper indicates that faster electrode speed with high rates of acceleration and response cannot be discounted with or without hollow electrodes.

I question the correlations of the results, however. While it may be true, that at optimum operating conditions the ratio between the active arc voltage and the transformer tap voltage is nearly constant, it should not be used, in my opinion, to correlate short circuit operating conditions—K and M factors in Figure 13. Further, why should the K and M factors be lower for the higher voltages, and larger electrodes, and higher currents? Why should the K and M curves meet at the 730 voltage, or any other voltage, electrode size, or current?

The optimum operating condition is the desired balanced operation. Any other operating condition needs correction immediately. At any unbalanced operating condition, the arc voltage ratios are far from nearly constant. We vary electrode motor speeds with them directly, from zero rpm to well over 100 per cent rpm. (That is not constant or even nearly constant.)

I believe the value of hollow electrodes should be studied further, as mentioned in the paper. We all should be anxiously awaiting further results from the study. Those indicated to date are interesting.

W. E. Schwabe: I would like to state that there is a definite mathematical relationship between what we call the active arc voltage and the tap voltage, and the power factors at optimum conditions. The active arc voltage between electrode tip and melt is equivalent to the open circuit voltage divided by two times the cosine or power factor at optimum conditions. This can be proved mathematically. It has been done.

On the other point, I think Mr. Vokac is right in questioning the accuracy of the presentation on plotting the K and M values versus the tap voltage. We were looking for a common denominator from a physical point of view. It seemed to us that the tap voltage because of the above defined relationship to the active arc voltage, is suited for this purpose, with a fair approximation. Since the effective arc length is proportional to the active arc voltage, the X-axis of Figure 13, actually represents the arc length used during the test.

A low tap voltage, in case of the 15-ton furnace, means a closer proximity to the electrode tip to the melt. The melt has a certain turbulence, waves, etc., and the possibility of creating short circuits under these conditions is relatively great. Increasing tap voltage means increasing the gap between electrode tip and melt. Assuming that the waves have the same geometry, only the more pronounced waves would get in physical contact with the electrodes at a higher tap voltage. Consequently, the number of short circuits is reduced.

I admit that the extrapolation of these curves to the value of 730 volts is an adventure and has to be considered as indicative only.

Walter Patterson: Does the ten per cent increase in electrode consumption include butt loss? Has any operator adopted the hollow electrode?

W. E. Schwabe: The increased consumption rate presented in the diagrams included butt losses.

Walter Patterson: If I understood correctly, you said the increased consumption was 10 per cent. Was that right?

W. E. Schwabe: The range is between four and ten per cent above solid electrode consumption. That included the butt losses. At the present time there is no general use of hollow electrodes. There are field trials under way. The project is still in an experimental stage.

. . . . few greases are compounded specifically for high temperature service . . . . most manufacturers offer a product to satisfy a variety of uses and therefore the high temperature properties are often sacrificed to help low temperature characteristics . . . .

High Temperature STEEL MILL GREASES

By

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▲ THE processing of hot steel unavoidably leads to high temperature lubrication service. Typical examples are found in the servicing of bearings used in furnace conveyors, converting vessel trunnions, sintering pallet wheels, soaking pit, cover cranes, manipulators, and blooming mill shear tables. See Figures 1, 2 and 3.

The lubricant must be so formulated and fortified as to withstand a variety of adverse conditions, such as heat, churning, water washing, and contamination. Failure of the grease to satisfy any one of the following requirements may cause difficulties. Details of ASTM tests may be obtained from the ASTM specifications. Other requirements covered by U. S. Steel test methods applicable to high temperature steel mill greases are given in more detail in this paper. See also reference (1) of Bibliography.

PERFORMANCE REQUIREMENTS

In anti-friction bearings, high temperatures may cause the grease to oxidize and harden or cake excessively. The theory that old grease is forced out by fresh grease is purely wishful thinking. This indicates the first requirement of *oxidation stability* which is covered by ASTM D-942, "Grease Oxidation By The Oxygen Bomb."

In plain journal bearings the grease may melt and run out, leaving the bearing dry and resulting in accelerated wear. This suggests our second requirement of a *high dropping point* set by ASTM D-566, "Dropping Point."

The primary function of the lubricant is to prevent wear. The third requirement of the grease then is satisfactory *lubricating properties*. A few of the tests used to evaluate lubricating properties are "Extreme Pressure By The Timken Lubricant Testor," "Extreme Pressure By Precision-Shell Four Ball E. P. Tester," and "Friction and Wear By Precision-Shell Four Ball Wear Tester."

Steel mills use tremendous quantities of cooling water. A grease unable to resist erosion or washing action of water is soon displaced by water—a poor substitute, indicating the fourth requirement of *water repellancy*, covered by the tests "Water Leaching" B.S.N.S. 14-L-5 and ASTM D-1264-53T, "Water Washout Test."

The grease may be retained in a ball or roller bearing for months, or even years, subjected to continuous working or churning. Some greases may liquefy and run out or others may harden and channel, pointing out the fifth requirement of *work stability*. Tests for this are ASTM "Grease Shear Stability By The Motor Matic Worker," "Shell Roller Test," and "Wheel Bearing Test."

The grease may be fed to bearings by pumps located 300 or 400 ft away, with one section of the supply line running along a furnace wall while another section may be out in freezing temperatures. This imposes another requirement *pumpability*. United States Steel has developed a test for this called "Grease Mobility." See Figure 4.

Frequently it is necessary to substitute greases, field test newly developed products, or in an emergency add anything that is available, so a further requirement may be *compatibility*.

Another desirable feature is *reversibility*, the ability to revert to its original or near original consistency after having been softened by churning and/or high temperatures.

In the bearings of motors in storage or infrequently used bearings in humid atmosphere, the lubricant should also possess the property of *rust prevention*.

Where the lubricant may remain in anti-friction bearings operating at high temperatures for long

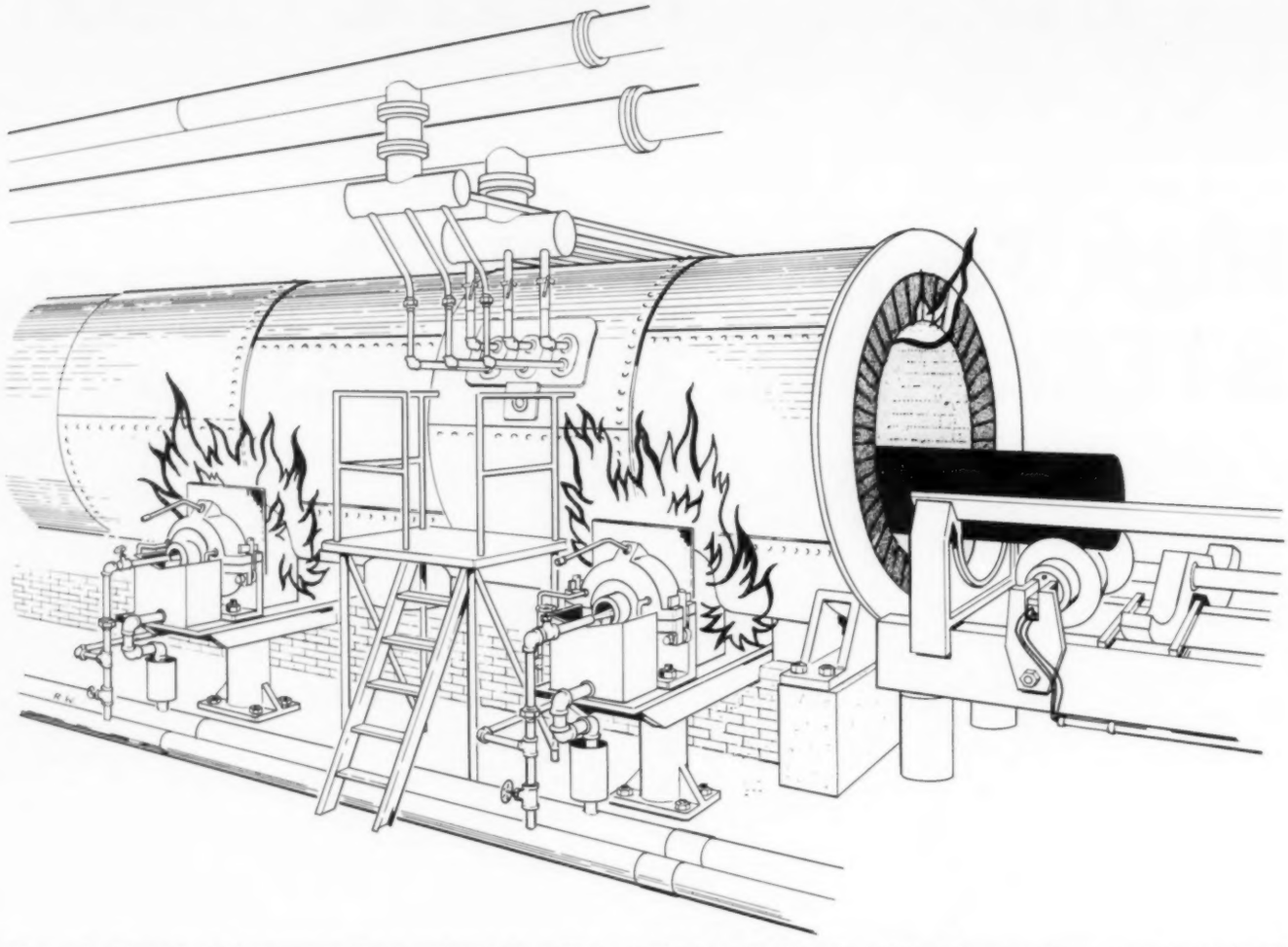


Figure 1—The reheat furnace on the seamless tube mill is a typical application for extreme temperature grease in steel mill operation. Other typical steel plant applications which require similar properties are the trunnion bearings on converters, sintering machine wheel bearings, and cover crane wheel bearings.

periods without renewal, the rate of evaporation of the base oil must be taken into consideration. The U. S. Steel test, "Static Heat Test" (Figure 5), is more severe than the ASTM or Army-Navy, and is used only on greases labeled for extreme temperature service.

EXPERIENCES WITH CENTRALIZED SYSTEMS

In centralized systems the grease is subjected to small clearances under high pressures and must possess the ability to resist excessive bleeding or separation of the oil and soap. This is checked in our plants by the "Pressure Oil Separation Test" (Figures 6 and 7).

The Graphite Abrasion Tester, ASTM Committee D-2, Research Division XII, Section C, brings to mind an unhappy experience of 10 to 12 years ago. A grease containing an inferior grade of graphite filler was first used. This was followed by another with an asbestos filler. The fillers probably contributed to the excessive wear that severely damaged the system. Today the lubricants testing laboratory forewarns when abrasive materials are detected.

Another experience with a filler (carbon black) had the opposite but equally distressing effect since it covered the plungers and cylinders of the measuring valves with a coating so tough that emery cloth was used to remove it to restore sliding fits. This carbon black filler also separated from the grease, accumulating wherever it encountered projections or pockets in the lines and measuring valves, thus effectively plugging the system. Oddly enough, none of these harmful effects were apparent in the bearings. In fact, if anything, these filler containing lubricants exhibited better anti-wear properties, longer retention, and tolerance to higher temperatures than conventional calcium-lead extreme-pressure greases.

Obviously, the answer is that the large clearances and rough surface finishes common to roll neck and table bearings will tolerate and actually benefit by the presence of the "body" of the filler which tends to fill in the low spots, presenting a smoother surface on both the journal and the bearing and acting as a secondary lubricant after the grease proper has been dissipated.

Can we expect any one lubricant to satisfy all of these requirements? The answer is a qualified "Yes." Through the past decade we have witnessed the development and gradual improvement and expansion of a group of lubricants known as multi-purpose greases that meet these requirements to some degree. Some may excell in a few of these requirements and be deficient in the rest; others may meet all of them to a moderate degree.

While we place no limitations on excellence at the National Tube Division, our lubricants testing laboratory has developed limits on deficiencies, or minimum

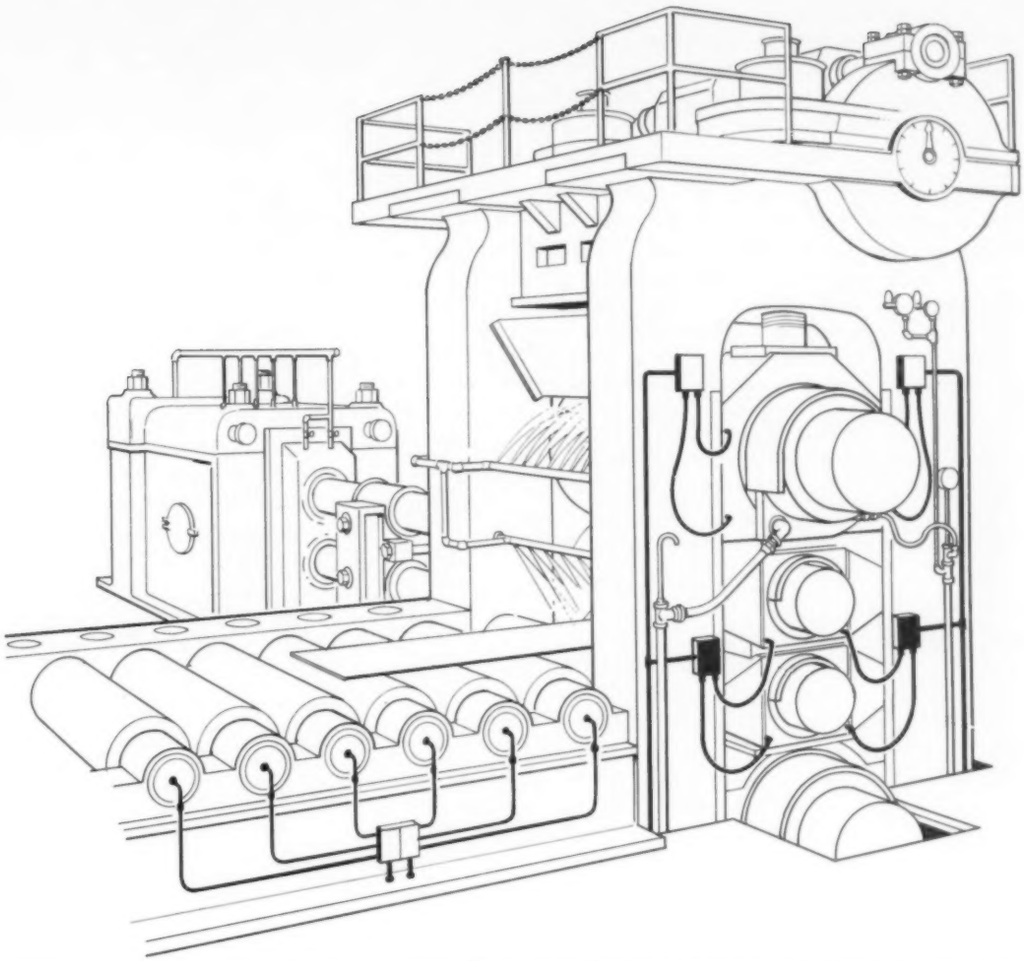


Figure 2 — Extra duty and extreme pressure greases are required on many rolling mill applications. Schematic shows four-high mill supplied by a centralized grease pump station. The extreme pressure grease contains additives which reduce galling and wear on the heavily loaded bearing. This grease is suitable for use at high temperatures of 200 F but not exceeding 250 F. Applications are backup roll, work roll, and table bearings which may be either plain bearings or antifriction bearings and also the thrust bearings under the screwdown.

values of performance that we call benchmarks. Table I shows a tabulation of performance requirements of lubricants in the moderate to extreme temperature ranges.

CHARACTERISTICS OF HIGH TEMPERATURE GREASES

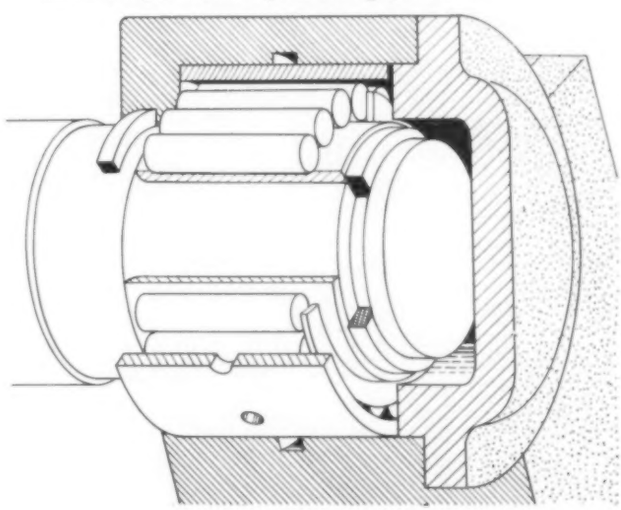
The line of demarcation, between bearings operating at normal temperatures and high temperatures, is generally accepted to be at 150 F. Hence, any grease that will perform satisfactorily above that temperature may fall within the scope of this discussion.

The number of factors that may affect the characteristics of a grease are so numerous as to be almost infinite. The type, volume and particle size of the thickener, the types and viscosity of the base oil, the types of additives and methods of manufacturing are a few. As a practical starting point, the greases are divided first into two major classes, synthetic and petroleum. Since the soap or the thickening agent is a predominating factor in determining the characteristics of a grease, they are further subdivided according to their thickening agent. This still leaves a fairly wide latitude. In any of these classifications, there may be high quality products or, conversely, products that are formulated strictly with low price as an objective. Throughout this discussion an attempt will be made to avoid both of these extremes.

Many engineers are familiar with the well publicized advantages of the various greases. However, if the grease has a weakness, or some undesirable side reaction in high temperature service, this is usually found through experience, from laboratory reports, or through meetings. One of the objectives, therefore, of this discussion is to bring to light these weaknesses.

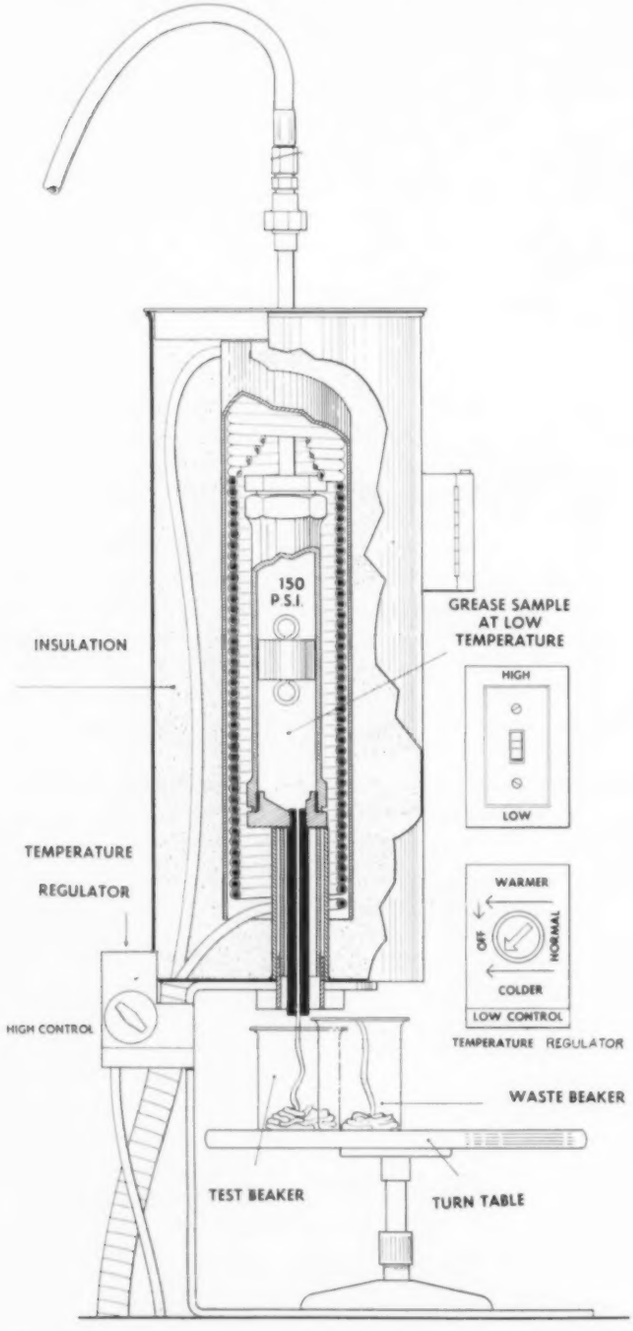
Disappointing performance of a lubricant in high temperature service is quite often not the fault of the lubricant, but rather its failure to live up to the expectation of the user, misled by advertisements that appear in some of the industrial publications, such as claims inferring, without actually stating, that since

Figure 3—Roll neck bearings are a typical application for extra duty, extreme pressure greases.



the grease will not melt at any temperature, it is usable at any temperature. Even if ignited, you need only put out the fire and the product will go on merrily performing its allotted task. In a remote sense those claims are vaguely true, only the time element has been left out. The grease will lubricate bearings at temperatures in excess of 500 F for a few minutes or even a few hours. However, the problem is to keep those bearings in service, not for a few minutes or hours, but for months or, if possible, for years.

Figure 4—Equipment shown was developed for testing pumpability. Test sample is placed in pressure viscosimeter and allowed to soak in cooling chamber until the prescribed temperature is obtained on the thermometer installed in the orifice. The flow of grease is started under a selected pressure set on a nitrogen tank regulator (not shown) transmitted through hose on top. After initial flow, grease is collected for given time to establish grams flow per second under the prescribed conditions. In a typical test, temperature would be 0 F, pressure 150 psi, resulting in 0.0 to 1.0 grams flow per second.



Usually overstressed and often misunderstood is the product's melting or dropping point. It has no direct relationship to service performance except in the limited sense that products cannot be used at temperatures higher than their dropping point.

While these advertisements will not mislead the lubrication engineers, they have and will continue to mislead men in the mill not quite as well versed in lubrication technology. The writer has, and no doubt many of other lubrication engineers have had, the unhappy experience of trying to explain away some of these exaggerated claims, but somehow the spoken word never seems to be quite as convincing as the printed word.

Figure 8 shows the relationship between the dropping points and the approximate maximum usable temperatures of the more common type high temperature greases. In using the chart as described, one may boast that it was prepared by a group of "experts," and truthfully so, for the shaded sections in the second line are in reality a consensus showing the highest and the lowest values found for a given group of greases as revealed by published data. In using this chart, please bear in mind that the *bottom* and the *top* of a shaded area *both represent* the same value; namely, the top temperature at which we may expect satisfactory performance from the lubricant. As an example, refer to the third shaded area from the top. The upper value of 350 F is one author's top limit of usability based on laboratory tests, 1000-hour life non relubricated bearings; while the bottom value of 250 F, according to another author's statement, "is generally considered the upper limit for satisfactory performance of petroleum greases." As stated above, the upper value is based on laboratory tests. Taking into consideration the more severe conditions of varying temperatures and loads, as well as contamination by scale, water, and mill dust typical of steel mill operating conditions, we are more inclined to accept the lower figure.

The point at which the line representing a given grease crosses the shaded area has no special significance. The fact that the "gel" greases cross at the top does not necessarily mean that they are better suited for that temperature than the sodium greases. Quality is significant since a high quality soda grease may by far out-perform an inferior "gel" grease. However, their relative position of crossing is indicative of their acceptance by the "trade" purely from the high temperature standpoint.

The next column, headed *common types*, needs no explanation other than that in some cases the listing is limited by the size of the brackets.

The next section, listing a few of the characteristics, is also limited by the size of the bracket, but since we will discuss the chart from top to bottom, additional characteristics will be revealed in the text to follow.

CHARACTERISTICS OF THE GREASES LISTED ON CHART

Synthetic (silicone)—The best known in the synthetic field are the silicones, usually thickened with

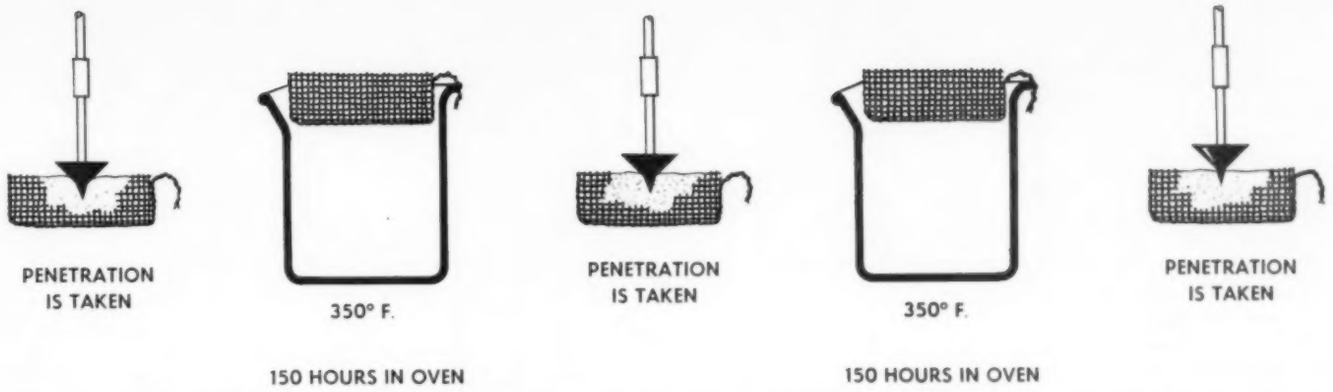


Figure 5—Static heat test is used only on greases for extreme temperature services and measures hardening characteristics under prolonged high temperature. In test, a sample of grease is placed on a small wire gauze container and ¼ scale cone penetration is taken at 77 F. The container is then placed on a 100-ml beaker placed in an oven at 350 F. Penetrations are made on samples after 150 hr and are repeated for final reading at 300 hr. The penetrations are taken at 77 F.

lithium soap or carbon black. They are highly resistant to oxidation and temperature change. Their maximum usable temperature may be well in excess of 500 F in relubricated bearings, but the top recommendation (by a producer) for sealed-for-life bearings is 200 F. Their primary weakness is poor lubricity, particularly in steel on steel application. Their wetting ability decreases with rising temperature; left too long in the higher temperature ranges they may revert to a silica like abrasive. Their life is rated about six to ten times that of a good petroleum grease. Even though quite expensive, justification of their cost is indicated in the life performance data shown as follows:

	At 150 C	At 200 C
Silicone grease, hr	8000	1580
Best petroleum grease, hr	845	
Poorest petroleum grease, hr	115	
Best diester grease, hr	1026	

Synthetic (polyglycol)—The polyglycols are the least expensive in the synthetic field. Their main advantages are that they leave no ash, gum, or abrasive residue; therefore, their maximum usable temperature equals their dropping point. They have high viscosity indexes and they are compatible with oxidation inhibitors, extreme pressure agents, as well as with petroleum greases. They are often used as a carrier for solid lubricants. In oxidation stability and lubricity they are equal to a good petroleum product. Possessing detergency, coupled with compatibility, indicates that the fluid polyglycols would make a satisfactory "rejuvenator" for hardened greases in sealed bearings.

An excellent review of synthetic lubricants may be found in the April, 1954, issue of Lubrication Engineering.

Petroleum, non-soap greases—Despite the fact that the word gel may be spelled four different ways, the producers of these greases refer to them as non-soap greases or absorbed oils. Between the *bentones* and the *silica gels*, the latter seem to be rated a little higher. Both are non-melting, compatible, and usually waterproofed, the better grades being fortified with rust and oxidation inhibitors. The silica gels are considered less corrosive and have better reversibility. The bentones do not soften with increasing temperatures, permitting

TABLE I

Requirement	Test method	Limitations	Normal temperature, extreme pressure	Extra duty, extreme pressure	High temperature, extreme pressure	Extreme temperature	Extreme temperature, extreme pressure
Oxidation stability	Oxygen bomb (ASTM D-942)	Maximum psi drop	...	...	20 psi	10 psi	20 psi
Dropping point	ASTM D-566	Minimum	190 F	250 F	350 F	500 F	500 F
Lubricating properties	Timken extreme pressure	Minimum lever arm load	40 lb	40 lb	40 lb	...	40 lb
	Shell four ball extreme pressure	Minimum weld point load	150 kg	150 kg	150 kg	100 kg	150 kg
	Shell four ball wear	Maximum scar diam	0.6 mm	0.6 mm	0.6 mm	0.6 mm	0.6 mm
Water leaching, per cent	Modified BSNS (14-L-5)	Maximum loss	2	2	2	...	5
Stability							
Shear	Motor Matic worker (ASTM D-217-A)	Maximum penetration change, per cent	10	10	15	10	15
Work	Shell roller, 4 hr	Maximum penetration change, per cent	25	25	25	15	25
Work and temperature	Wheel bearing	Maximum loss, per cent	10 (3 hr @ 150 F)	2 (3 hr @ 200 F)	5 (6 hr @ 235 F)	2 (6 hr @ 235 F)	5 (6 hr @ 235 F)
Pumpability	U. S. Steel Method gm per sec flow 150 psi @ 0 F	Minimum centrifugal systems	0.01 or 0.1 gm*	0.01 or 0.1 gm*	0.01 or 0.1 gm	0.01 or 0.1 gm	0.01 or 0.1 gm

* If pumpability is critical.

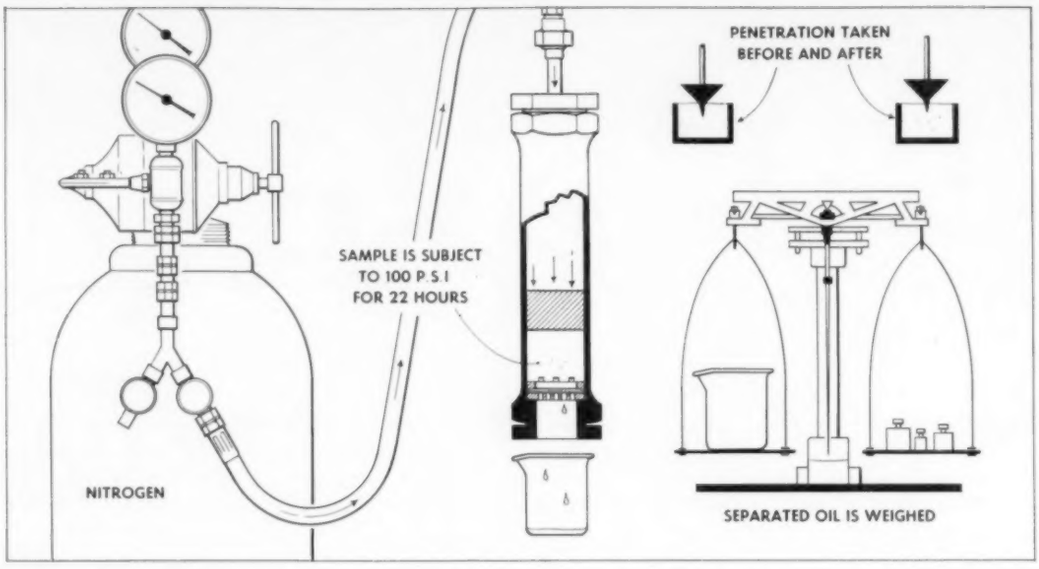
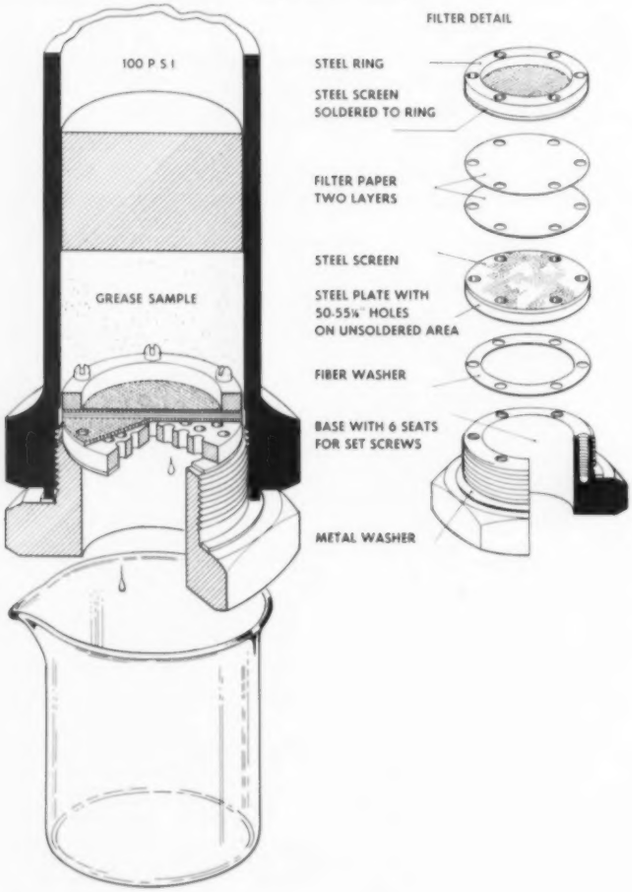


Figure 6—In the pressure oil separation test procedure, 50 grams of test sample are charged through a Standard Oil Development tube. The piston is placed and the filter unit is then screwed in and tightened with wrenches. Tube is attached to a vertical post, connected to a nitrogen cylinder with flexible hose at the pressure regulator. A 100-psi pressure is built up in a two to three-minute period in the tube. A tared beaker in the unit collects any oil which may separate. After 22 hr the oil is weighed and the tube disassembled. A penetration test is taken on the layer of grease (usually ¼ in. in depth) closest to the filter unit.

the use of lighter grades in high speed anti-friction bearings.

Carbon black was one of the earlier absorbent type jelling agents. It enjoyed wide popularity for several years until its major weakness was discovered, that of separating under high pressures and plugging small lines and pressure systems.

Figure 7—Schematic shows components of equipment used in pressure oil separation test.



Asbestos—Some call it a filler, others an absorption type jelling agent. In the latter sense, it belongs in the group shown. Having a melting point of approximately 350 F as against 500 F for the others, it does not belong.

Petroleum soap type grease—Barium—Among the soap type greases the barium appears to have better high temperature characteristics than the others. It has the highest dropping point, is resistant to both fresh or salt water, has good work stability and reversibility. Barium has high polarity; that is, ability to stick to metal surfaces which gives it natural mild extreme pressure properties as well as rust prevention. It expands considerably in service; therefore, do not overpack sealed bearings. On the debit side, it is not compatible, has poor low temperature pumpability, and is expensive.

Sodium—Soda soap greases are available in such wide varieties that it is impossible to describe one and call it typical. Their drop points may range from approximately 300 to as high as 400 F, the best of them being usable to their melting points. In general they are more stable than the calcium greases, resistant to bleeding and separation under high pressure. Though they go through a temperature phase change, their reversibility is rated good. They resist separation under high centrifugal force, therefore are good in high speed anti-friction bearings and couplings. Being water soluble they will wash out, but will absorb small amounts of moisture, also provide an alkaline reaction and are, therefore, good rust preventives under mildly wet conditions.

While some rate sodium above lithium for high temperature service, the writer's personal experience has been to the contrary. In each of three long range trials under different conditions, the result was the same; the light ends apparently evaporated, causing the grease to thicken excessively. In one trial it plugged the dispensing system, in the other two it channeled badly, resulting in excessive bearing wear.

Lithium—There are two distinct types of lithium soap greases, the "basic" and the "12 hydroxy stearate." This really should have been shown by two lines on the chart. The dropping point of the "basic" is about 350 F and for the "12 Hydroxy" about 380 F. The characteristics of the "12 Hydroxy" type are better

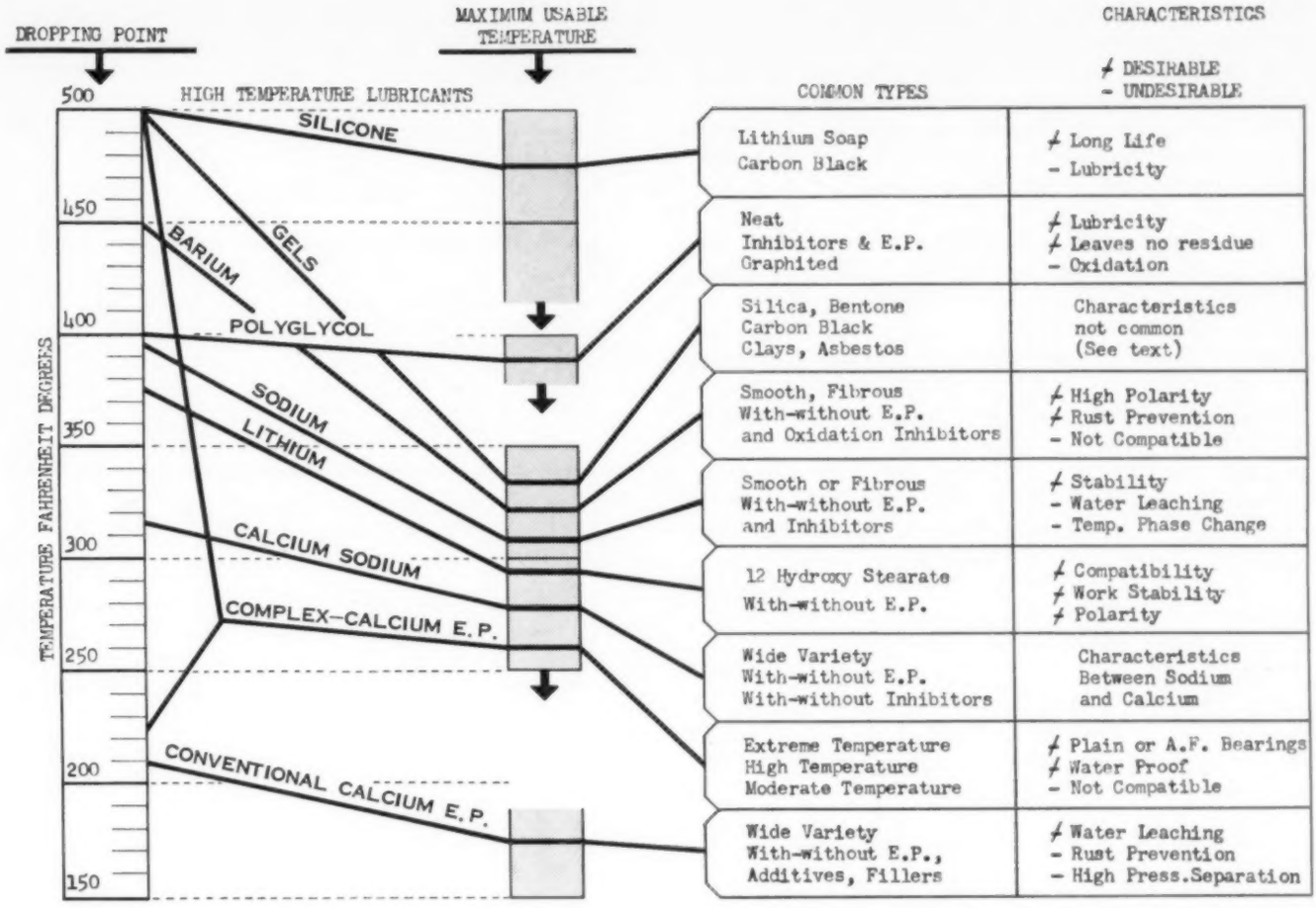


Figure 8—Chart gives relationship between dropping point and maximum temperature usability of high temperature greases.

than the "basic" right down the line. Lithium greases will absorb 20 to 30 per cent water before breaking down, possess excellent pumpability, and are compatible. The "basic" is deficient in work stability. The polarity of the lithium soap is about 75 per cent of the barium. Lithium soap is not too compatible with rust preventive and extreme pressure agents. MacDonald and Dreher in a paper on "Additives for Greases" show that after a month in storage the Timken load value dropped from the original 40 to 25 or 30 lb. Currently, use of the "basic" is declining, while the "12 Hydroxy" type is leading in the multi-purpose field.

In some lifetime sealed bearings the lithiums fell somewhat short of expectations. For hardened greases in such bearings, a rejuvenator fluid is now available that may be injected by means of a hypodermic needle.

Mixed base soda-lime—The better grades are made with choice oils and selected fats, and are costlier than the straight soda or lime. They tend to combine in one grease some of the advantages of both soaps. With the soda soap usually predominant, their characteristics more closely approach that of the soda greases. They resist separation under pressure and centrifugal force, and are moderately resistant to water leaching.

Calcium complex extreme pressure—The calcium soap (calcium salt) extreme pressure greases are relatively new and still undergoing modification and improvement. The currently available products may be roughly divided into three groups:

1. Moderate to high temperature range offered as improvements over the conventional calcium extreme pressure to fill the gap between the calcium and sodium greases. Their dropping points may range from 225 to 280 F.

2. High temperature products, formulated to compete in the multi-purpose field, with dropping points in excess of 400 F.

3. Extreme temperature field where their 500 F+ dropping points, coupled with extreme pressure properties, may offer advantages over the "gels." Several products in this group, tested at our laboratory, have surpassed the benchmarks shown in the last column of tabulation of minimum requirements (Table I).

Generally they are of smooth, buttery texture, satisfactory for plain or anti-friction bearings, are waterproof and have good low temperature pumpability. On the debit side they are not compatible with other greases, some become stringy at sustained high temperatures, and some have a tendency toward bleeding and separation in storage.

Conventional calcium extreme pressure—These are not usually classified as high temperature greases, but are frequently employed in borderline cases or even at temperatures well above their known limitations. For example, in centralized systems serving 200 to 300 bearings in a hot rolling mill with approximately 10 per cent operating in the high temperature range, a separate system for these few bearings or use of the costlier high temperature lubricant in the system may prove to be economically unsound. As a compromise

for economy, calcium extreme pressure greases are used, with bearings in the high temperature zones favored by more frequent and/or larger "shots." They are more widely used in steel mills than all other greases combined. Better known in mills as general purpose or pressure gun greases, they are usually fortified with three extreme pressure agents; lead, sulphur, and chlorine.

Their dropping points range from 190 to 210 F. Approximately ½ to 2 per cent water is used as a bonding agent which limits the upper temperature usability at 160 to 180 F. At these temperatures, the water is lost through evaporation, permitting the grease to separate into its original oil and hard soap. They are smooth and suitable for both plain bearings and high pressure, low speed anti-friction bearings. They are waterproof and will resist washing out. Unfortunately they separate under high centrifugal force (not good for high speed anti-friction bearings and couplings) and at high pressures. The magnitude of the high pressures is not stated, but from experience, at pressures of 1200 lb, we have found no evidence of such separation in over five years of service in our pressure systems. Since rust prevention and water repellency are usually associated, the minus mark before rust prevention may require an explanation. The theory is that waterproof greases will not absorb moisture, but may actually trap droplets of water in dormant areas of the bearing.

THE EFFECT OF ADDITIVES

Additives usually found in high temperature greases include anti-oxidants, rust preventives, extreme pressure agents, stringiness agents, etc. Excluding the anti-oxidant, all of them will have a negative effect on oxidation stability.

The non-waterproofed, non-soap (gel) greases break down in the presence of water; waterproofed, they become deficient in anti-rust properties. Rust preventives and extreme pressure additives may adversely affect the function of the thickener, causing the grease to become softer and less stable at high temperatures. All additives have high temperature limitations. Waterproof coatings oxidize at 250 F or higher. The approximate upper temperature limits of the commonly used anti-oxidants are shown as follows.

Types of Anti-Oxidants

Type	*Approximate upper temperature limit of use, F*
Phenolics	250
Aromatic amines	300
Dialkyl selenides	325
Phenothiazine	350

SUMMARY

There are relatively few greases compounded specifically for high temperature service. The manufacturers' interest is best served by a product that will satisfy a variety of uses (multi-purpose); hence, high temperature properties are often sacrificed to enhance the product's low temperature characteristics.

The solution to a high temperature problem may not always be the obvious, find a better lubricant. We may take a lesson from the following: A well known chewing-gum manufacturer, after spending several years and several million dollars to develop a chewing gum that would not stick to false dentures, eventually solved the problem in reverse. He developed a denture that would not stick to chewing gum.

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DISCUSSION

PRESENTED BY

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J. D. LYKINS, Chief Lubrication Engineer, Wheeling Steel Corp., Wheeling, W. Va.

CHARLES T. LEWIS, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Construction & Engineering Dept., Bethlehem, Pa.

Edward J. Gesdorf: Considerable wide-spread benefits have resulted from the practical lubrication information that has been freely distributed by the National Tube Company's lubrication department. At this moment, I am reminded of the "Lubrication Engineers Manual" which is published and distributed by the National Tube Company. I have seen copies of this manual in the hands of men all over the United States and in the hands of men as far away as the South American country of Venezuela.

The paper just presented on the subject of "High Temperature Steel Mill Greases" gives us an insight into the complexed chemical problems that lubrication engineers are faced with in the selection of a suitable grease for a high temperature application. We as manufacturers of lubricant dispensing equipment have an interest in this problem, as today more than ever before the centralized lubricating systems that we produced are needed to:

1. Eliminate personal injury hazards.
2. Assist in securing uninterrupted production.
3. Prolong the life of machinery.

To lighten the burden placed on lubrication engineers,

we are continually striving for improved centralized lubricating equipment that make it possible to move the lubricant to the bearings automatically through adequate diameter conduit and adequate diameter measuring valve porting. We find that by providing low pressure operating characteristics in a centralized lubricating system, the problem of grease separation resulting from pressure filtration is avoided. One additional concept in successful centralized lubricating equipment is the importance of moving the grease directly to the bearing without working the lubricant excessively. Pumps with adequate discharge capacity should be employed in the centralized system so that the lubrication job can be done quickly. This gives protection against wear and leakage as the system service life increases.

There have been a few instances where grease containing abrasive graphite has been dispensed through a centralized lubricating system. This was done knowingly, and the centralized system was considered expendable. Automatic application of the lubricant was of such importance that the means was justified by the end result. However, when abrasive lubricants are applied without full knowledge of the consequence by the user, a considerable number of problems and misunderstandings evolve. For this reason, we are pleased to see that mention was made of the graphite abrasion test in Mr. Simon's paper.

Mr. Simon stated that some of the high temperature greases have a high coefficient of expansion. This characteristic can cause trouble in a centralized system that is installed with long discharge lines from the measuring valve to the bearing. Greases with high coefficient of expansion will create a thermometer effect in pipe line, and if the temperature changes are frequent and cover a large range, voids will be found in the lines. This can lead to improper bearing lubrication.

Two other important laboratory tests were mentioned in Mr. Simon's paper. One was the "Pressure Oil Separation Test" and the other was the "Grease Mobility Test." Both of these tests are according to United States Steel standards. The importance of these tests is such that we would like to see comparable test standards set up by ASTM or NLGI that would make separation stability and pumpability information available as part of the typical specifications on greases.

George E. Crouch: As Mr. Simon pointed out in his paper, the complex soap grease family, along with the soapless group, are undoubtedly the greases that at this time are arousing more than their share of interest. Speaking specifically of the complex soap group, one author has stated that conservatively speaking, probably more than half of the new lubricating greases produced today contain a complex soap, but be that as it may, considerable work with promise still appears to be going ahead currently with calcium, barium, strontium, and other soap complexes.

Chemically, any grease which deviates from the conventional normal or basic soap formation, such as calcium, sodium, lithium, etc., falls into the complex soap category. Normally speaking, the terminology of complex soaps refers to a soap-salt combination, such as where a normal metallic soap is combined with a salt of a low molecular weight acid such as calcium soap in calcium chloride complex, strontium soap in sulphonic acid complex, or sodium soap in thio-ether acid complex, and many others. Initially, interest was aroused to these soap-salt complexes since this is a means of obtaining higher dropping points in the grease. It is not uncommon for a basic soap grease that will have a normal dropping point of 175 F that when made from a soap-salt complex, its dropping point becomes in excess of 400 F, and thereby increasing its field of application to industry as a whole.

Some of these products show exceptional stability in their aggregate or finished state, covering a very wide temperature range, and many grease chemists consider the complex soap greases high solubility characteristics as extremely desirable and important.

At the present time, complex soaps and greases are very much what the name implies—complexities. The experience of grease makers indicates the chemistry of complex soaps is not particularly simple. We are, however, learning more about them every day.

For some time now calcium complex soap greases have given very creditable performance, but on the other side of the ledger, there are more than a few which performance-wise have given some excellent service in high-temperature lubrication, but at the expense of other desirable requirements, such as compatibility, separation during long-time storage, some even becoming abrasive at certain critical temperatures and many showed poor mobility when used in a low-temperature application, thus making these products not suitable for a multi-purpose use.

As previously mentioned, this is a comparatively new field, but one where considerable promise shows forth and could well hold the answer to Mr. Simon and industry's request for a multi-purpose lubricant.

I believe Mr. Simon is to be complimented on his very thorough and practical approach to a problem that is being given more consideration by heavy industry each year, and that is the use of a high-temperature multi-purpose grease. Now not referring to the complex soap greases, but to the generally accepted high-temperature type grease, such as lithium, silicons, and polyglycols, I readily agree with Mr. Simon that when correctly applied in the proper application, they satisfy a very real need. Naturally, any paper on this subject cannot but help raise questions in the minds of suppliers and users alike that will help us approach this from a more practical standpoint. One question I would like to address to Mr. Simon is:

Since your plant is representative of a multi-operation industry, I would like to ask that in relation to your total grease requirements for a year, what percentage of your grease requirements fall into the high-temperature classification?

John Simon: Our inventory of high temperature greases is somewhere between 5 and 10 per cent. However our actual requirement could be well above that, since much of our border-line or near high temperature applications are met with conventional products as described in the first paragraph under "Conventional Calcium Extreme Pressure." I believe the practice is quite common.

B. B. Flick: In commenting on a paper of this scope, I find it quite difficult to make statements other than those in agreement with the general content. It is evident that Mr. Simon has spent considerable time

and exercised a great deal of care in arriving at conclusions regarding various types of greases, chemical treatments, applications of tests.

There is an opportunity here, however, to comment by way of emphasizing what we consider to be points sometimes glossed over in our general attitude toward greases. Even the specialists, in these lines, are often hasty in arriving at conclusions concerning the various types of greases.

One such item is that of the oxidation stability as measured in the oxygen bomb tests, procedure outlined under ASTM D-942. This test was established as a means of measuring relative resistances to oxidation breakdown under static conditions. This is a most important item, in view of the present practice of lubricating bearings and other mechanical parts, which may be subjected to long term storage, under many extremes of temperature and humidity conditions. Therefore, because the grease is tested under static conditions, results cannot be applied to the prediction of life under dynamic or operational conditions in a machine. To put it another way, there is no basis for assurance that a grease, passing the oxygen bomb tests, will necessarily show exceptional oxidation resistance in a bearing under working conditions.

Mr. Simon listed, among the various types of greases, the mixed base type of soda-lime. It would be well, also, to include aluminum-soda base greases in this category. Certain of these types will have a dropping point of 300 F minimum, and a serviceable working range in excess of 200 F. Aluminum-soda greases have good adhesive as well as cohesive qualities, excellent water repellency qualities and, in general, have given very good service in the application for which they are intended. Mr. Simon's point that the failure of greases in high temperature service is not always the fault of the grease, is well taken. The success or failure of the lubricant is dependent, also, upon the correct selection, application, quantity applied, frequency cycle. It is generally agreed, that one grease may satisfy two different temperature conditions even though the temperature spread is quite wide. However, the frequency of grease application may be greater for the higher limit of temperature.

Mr. Simon's remarks on the relationship between the melting or dropping point and the temperature range, through which the grease is used, are quite appropriate. We have found, in many cases, that a user often expects a grease to perform as satisfactorily at its melting point as it does in its recommended temperature working range.

It is generally agreed, as the author states, that the "twelve hydroxy stearate" lithium soap grease resists breakdown to a marked degree. However, the so-called "basic" lithium soaps, as referred to, have proved very serviceable for many applications, especially those where long storage or static conditions are not encountered or where renewal of grease can be accomplished. The difference in cost between these greases and the "twelve hydroxy stearate types" suggests the desirability of appraising the conditions before deciding which type to use.

Compatibility of extreme pressure additives with lithium greases, referred to by Mr. Simon, is an interesting subject. The point made by him as to the drop in extreme pressure characteristics during storage has been discussed many times. The writer cannot comment, at this time, although he would have liked to have conducted some check tests prior to this meeting. These would have involved checking film strength characteristics of a new batch with ensuing tests at intervals for a period of several months.

Wayne G. Ritter: This paper presents a concise, clear definition of the various properties of lubricating greases. It could well be used by steel plant maintenance departments as general indoctrination literature for use by all personnel concerned in any way with lubrication. The author is to be complimented.

Lubrication equipment manufacturers are vitally concerned with the performance of greases in their centralized systems. In modern steel plants in which centralized systems are now standard equipment, a key phrase is: "a grease that won't pump, won't lubricate."

Great strides have been made in the past seven or eight years by lubricant manufacturers in compounding greases with properties which have made them easily handled in centralized systems. "Separation" or "bleeding" in systems is now a rare exception, rather than the rule. Neither does any particular make of equipment have a monopoly on this phenomenon.

Some cases of separation were observed with early lithium soap greases. This separation usually occurred in pump reservoirs which were pressure loaded with a spring or compressed air. The conditions under which separation in pump reservoirs occur are duplicated in the pressure oil separation test. If separation in pump reservoirs or in the newly opened grease drum is observed, it can generally be expected that some separation will occur in the feeder valves.

The lithium soap greases with an extreme pressure additive have not shown a tendency to separate in centralized systems.

A few years ago some systems installed on blast furnace tops had steam tracer lines in proximity to the grease lines running up the skip bridge. Such a practice in some cases led to the charring of grease in the lines. With the great improvement in mobility properties of greases, this practice of heating lubricant lines is, as far as we are concerned, obsolete.

As for using centralized systems in high ambient temperatures, it is well to remember to keep the lines small and keep the grease moving in them.

J. D. Lykins: To add materially to the paper presented would be difficult, however, in regard to calcium complex greases, we have found some greases that are more susceptible to water than others. Some will thin out or increase in penetration number, while others will harden or decrease in penetration number when worked in the presence of water. The mechanical stability varies widely and since calcium complex greases are being used more widely in the steel industry, they should be scrutinized very carefully in selecting them for any particular application.

Charles T. Lewis: The author mentioned the long tube method of pumpability testing. It is possible that some of the other consumers will run into difficulties along the lines of pumping problems. In the latter part

of 1952 and the early part of 1953, our lubrication committee began some testing and checking on this method and compared the results with the established tests and the pattern followed very closely. There is one additional advantage in the tube method in that the amount of equipment involved is considerably less, and it is much more portable, particularly in view of the extended temperature range over which it is run, either to the high temperature limits or to the extremely low temperature limits. The results are very fine.

John Simon: We have not had pumpability troubles for so many years that when we did encounter it recently we had difficulty recognizing it. Our experience indicates the need for an improved pumpability tester and we are currently experimenting with a long tube tester. I have been unable to find any papers on the subject and I would greatly appreciate any advice that you may have to offer.

Charles T. Lewis: Temporarily, the one we started out with was a 25-ft length of ¼-in. tube on an 18-in. helix. One of our suppliers is presently using 100 ft of ⅜-in. tube on some elevated temperature tests and the results look very promising.

A. E. Cichelli: We in Bethlehem Steel direct most of our testing to spot field applications. Having experienced disappointments in products that looked good in the laboratories, we have learned to rely almost entirely on these performance tests. Whenever we can most nearly duplicate a field condition in the laboratories, then of course time can be saved. For example, we have done just that in the development of new wire rope lubricants.

The author states that high temperature greases represent about five to ten per cent of his plant's total consumption. This is generally true of our own practice. As might be surmised, this volume represents a rather important percentage as it serves those applications that give us the most trouble. Equipment suppliers recognizing this condition should do their utmost to design their equipment to reduce this percentage. On the other hand, it is re-assuring to know that where it is impossible to avoid high bearing temperatures, products are on the market that perform generally satisfactorily.

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ELECTRICAL MAINTENANCE at Pueblo Plant of the Colorado Fuel & Iron Corp.

By HAROLD E. WATSON, Electrical Superintendent, The Colorado Fuel & Iron Corp., Pueblo, Colo.

▲ THE Pueblo plant of the Colorado Fuel and Iron Corporation is an integral steel plant consisting of coke plant, blast furnaces, open hearth, rail, 40-in. blooming, 20-in., 25-in., 14-in., 10-in., rod, seamless tube, bolt and spike, and wire mills. The plant covers 565 acres and has an annual ingot capacity of approximately 1,500,000 tons and a current employment level of 8800.

The electrical department is responsible for all electrical maintenance, supervision, and coordination of electrical construction, operation of the electric shop, and supervision of electrical crane operation. The full scope of electrical maintenance problems in the steel industry is encountered in this plant. These problems are complicated by the location of the plant, away from any heavily industrialized area, so that maintenance facilities must be entirely self-sufficient. Complete electrical and mechanical maintenance shops are operated, so that any breakdown of equipment can be repaired by plant facilities.

The plant at Pueblo was first established in 1882, primarily to produce rails for western railroad expansion. With the exception of new facilities added since 1946, which include the new rod mill, the seamless tube mill, and some wire finishing facilities, the various mills are housed in buildings constructed prior to 1930, and many of them date back to the turn of the century, so that plant operating and maintenance problems are further complicated by old buildings and the limitations of space and handling facilities characteristic of such buildings. When steam-driven main drives were replaced with electric motors in 1926, these drives were installed in the old machine rooms, and no provision was made for conditioning or cooling. The electric shop itself is housed in one of the oldest buildings in the plant.

Every effort is made to utilize modern developments in equipment and to continually improve and renovate existing equipment. In so far as electrical equipment and its maintenance is concerned, the same problems are encountered that exist in the older established steel mills in the East as well as in the plants built within recent years.

The electrical department is established as a separate department with the superintendent reporting direct to the works manager. The supervisory organization as shown in Figure 1 divides the department into four principal subdivisions: the electric shop, crane operating division, electrical maintenance and construction, and crane maintenance. Electrical maintenance is organized on an area basis, with a foreman electrical inspector in charge of each area. These areas do not necessarily coincide with operating sub-divisions of the plant, and in this respect the organization here varies from that normally encountered in a steel plant. Assigned maintenance and crane operation in the open hearth are under the direct control of the open hearth.

It is impossible to indicate on an organization chart the close co-ordination required between the electrical, mechanical maintenance, engineering, and purchasing departments to accomplish economical electrical maintenance and modification of equipment and the development of new facilities. The electrical department takes a part in the selection and design of electrical equipment from the time a project is first conceived. The superintendent or his designated representative works closely with electrical design personnel in the engineering department. No engineering force, as such, exists

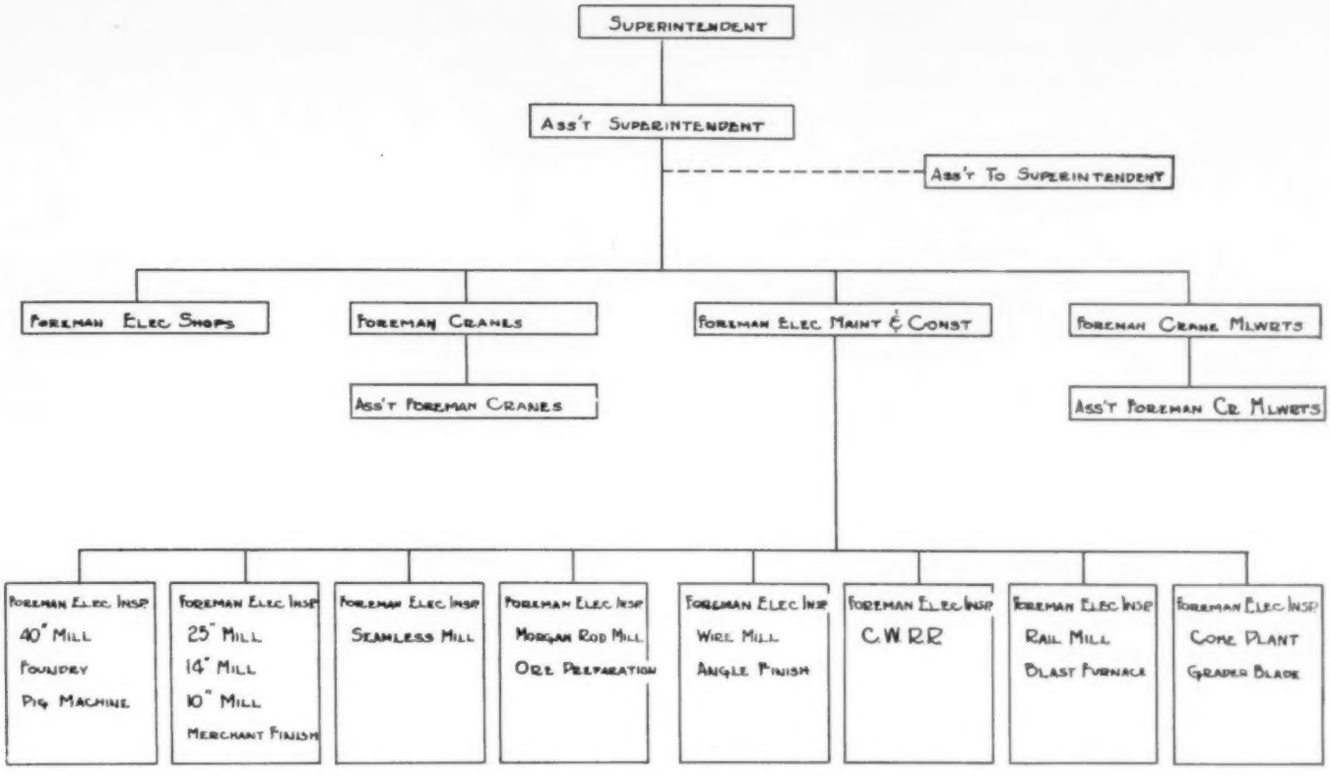

Figure 1 — Organizational chart of electrical department

in the electrical department itself, so that the electrical design crew within the engineering department becomes, in effect, an arm of the electrical department superintendent. Illustrating this point could be the installation of individual motor drives on wire fabricating equipment in place of shaft drives; such a project would be the concern of the electrical department from the time of its first conception until the installation had been completed. Similarly, the electrical department was consulted and took a part in the selection and specifications of equipment for the new seamless tube mill, and the problem of economic maintenance was considered from the first phase. A similar relationship exists between the purchasing department and the electrical department in the purchase and selection of spares.

Through this method of operation, a program has been developed that results in a high level of equipment standardization. Specifications for new equipment are written toward a milti-purpose use. Every effort is made to standardize on common makes and types of motors and controls. When selecting new equipment, a review of existing similar equipment is made to see whether or not an existing unit or spare can be utilized. This thinking and planning results in fewer varieties of spares in inventory and in simplified maintenance. There is no necessity of carrying a complete set of spares for each operation, nor must electricians be specifically trained for each part of the plant.

Control of electrical spares inventory is co-ordinated through the electrical department, working with and through the storehouse, which in the CF&I, is under the jurisdiction of the controller. The quantity and type of spares stock are established by the electrical department and renewed on electrical department order.

All of this requires close coordination and cooperation by the personnel of the various departments and is the outstanding characteristic of the Pueblo organization.

Electrical maintenance in all steel mills follows a generally consistent pattern for auxiliary equipment, in that spare motors for a-c drives and armatures for d-c drives are kept on hand. This holds true also for both main and auxiliary drive controls. The Pueblo plant practice varies from normal in that no spares are carried for main drives. A spare unit for a main drive has never been purchased, but rather maintenance of such drives is dependent upon the electric shop's ability to repair or rewind the unit and return it to service with a minimum of delay. This method of operation has proved effective at Pueblo in that no outside facilities have been called upon to make repairs, and in few instances has it been necessary for operating units to suffer delays due to unscheduled or emergency repairs. This result is due in no small part to the close co-ordination between operating supervision, the mechanical maintenance organization, and the electrical department in planning for necessary maintenance of facilities.

This also illustrates that the electric shop is the heart of the electrical maintenance program at the Pueblo plant. It is manned to be able to perform any repair or rebuilding job, and the goal of its personnel training is for each craftsman to be able to do a complete job. Rather than stocking finished coils for motors, controls, etc., reels of wire of the sizes and insulation which experience has shown to be necessary are carried in stock, and coils are rewound and rebuilt as required for particular repair jobs. This has a number of advantages:

TABLE I

Electric Shop Force

Number per day	Occupation
1	Foreman
1	Shop leader—special
1	Armature winder leader, field
16	Armature winder
1	Coil maker leader, special
1	Repairman—lifting magnets
1	Armature lathe man
1	Machinist
1	Tool room repairman
2	First mechanic—tool room
1	Babbitt man
1	Shop helper (tool room)
1	Repairman controllers
6	Coil winder
3	Helper—coils
2	Repairman—water cooler
1	Truck driver
1	Sweeper
1	Toolroom man
4	Apprentice armature winder

first, the material carried in inventory in the form of wire provides for substantial savings in the purchasing of material; second, the inventory is flexible; third, the inventory is of less value in dollars than an inventory of spare units; and fourth, this provides a basic work load for the electric shop so that sufficient personnel can be carried and made available for any major emergency repair job that may be encountered.

Some examples of how the electric shop can function in an emergency are:

1. A 1200-hp, 450-rpm, 6600-volt, wound-rotor, induction motor was taken out of service, 14 coils rebuilt, replaced in service without handling facilities other than jack bolts and stator shift, in 40 hours. This unit remained in service nine years following repair.

2. Two field coils wound directly on the pole pieces for a 1500-hp, 514-rpm, 6600-volt sychronous motor were rewound and the motor returned to service in 20 hours to cover the failure of the manufacturer to deliver replacements as ordered.

3. Generator armature coils in a 1000-kw, 250-volt, d-c generator were rebuilt and replaced in 96 hours.

Shop costs are watched closely. Each job processed through the electric shop is handled on shop orders so that detailed costs are always available. These are compared regularly against quotations from outside facilities for the same work, in order to assure that the plant's shop is paying its own way. Currently, the cost of operating the electric maintenance shop, including labor, materials, and shop overhead, is approximately $0.25 per ton shipped. The shop force now consists of 32 men; authorized manning is tabulated in Table I.

The electric shop repairs and rebuilds electrical equipment that cannot be repaired in the field. Field repairs are under the supervision of the general foreman-electrical department and the foreman inspectors in various mill areas. Table II gives the manning of these various assigned areas of electrical maintenance. The electrical inspectors are in a plant-wide seniority unit and may be assigned to any area, dependent upon the need. The foreman inspector in his assigned area is in charge of all electrical maintenance in that area and is expected to be familiar with all electrical equipment. Further, he must maintain an adequate supply of spares on his area, coordinate electrical maintenance work with the operations and with mechanical maintenance crews, and instruct and supervise the inspectors and helpers assigned. To accomplish this, the foreman is acquainted with any changes or improvements as these changes may be conceived or developed, and frequently his recommendations will be reflected in recommendation for improvement in design or specification. All of the foreman inspectors have been developed within the electrical department organization. This supervision exists normally on day turn only, although the responsibility for that area is a 24-hour one for each foreman. It has been necessary to assign supervision on afternoon and graveyard shifts only at the seamless tube mill, which, from an electrical point of view, is the most complex unit within the plant.

Performance of assigned electrical maintenance at the seamless tube mill may be of interest. During two and a half years of operation from startup, electrical delays have been reduced to 1.3 per cent of operating time. This force covers both the hot mill and finishing units, including billet peelers, conditioning, quench, draw, normalizing, and coupling shop, as well as the normal complement of equipment in a seamless tube mill. This is accomplished with a force ratio of 26.56 manhours per 100 tons produced.

The assigned maintenance organization is supplemented from time to time by the assignment to specific jobs of electrical linemen and wiremen from the construction crew. When working within an assigned area on repair or renovation of equipment, these men are

TABLE II

Assigned Electrical Maintenance Per Day

	40-In. mill foundry pig machine	10-In. mill 14-In. mill 25-In. mill merchant finishing	Seamless mill	Ore preparatory rod mill	Wire mill angle finishing	C.W.R.R.	Rail mill blast furnace	Coke plant, grader blade	Misc.
Foreman electrical inspector	1	1	4	1	1	1	1	1	
Relief foreman				1					
Electrical inspector	3	7	6	6	6	2	7	5	9
Electrical inspector helper	4	7	6	4	5	2	5	5	7
Motor operator		6	3				3		
Sub-station operator		3							
Motor room attendant				3					
Total	8	24	19	15	12	5	16	11	16

TABLE III
Electrical Delays—Per Cent Operating Time

	10-Year average	December, 1955
Rail mill	1.03	0.28
40-In. mill	0.71	0.27
25-In. mill	1.67	1.19
14-In. mill	0.64	1.19
Rod mill	0.49	0.34
10-In. mill	0.95	0.67

TABLE IV
Electrical Inspector Hours Per 100 Tons Produced

	Manhours per 100 net tons produced
Seamless mill	26.56
Wire mill	11.17
Rod mill	6.47
Blast furnace	0.94
Rail mill	4.18
40-In. mill	4.27
25-In., 14-In., 10-In., and merchant finishing	11.74
Coke plant	2.80
Ore preparation	0.63

also under the supervision of the foreman electrical inspector.

In following through the full responsibility of the department, the foreman inspector of a given area is brought into the selection and design of new equipment and is familiarized with any new installation well ahead of its operation. For instance, during the construction of the new seamless tube mill, the foreman inspector for that area was appointed and assigned to work at the time electrical equipment began coming into the plant. As a result, he was more familiar with the equipment and its operation at the time the mill started than would have been possible otherwise. This has resulted in an extremely low electrical delay ratio for the seamless tube mill during the first two and a half years of its operation. It may be of interest that at the time the mill started operation, only three individuals in the plant were familiar with seamless tube mill operation.

In Table III are tabulated electrical delays experienced in the various rolling mills at the Pueblo plant. Electrical maintenance costs are watched closely. Indicative of the cost of electrical maintenance are the total electrical inspector-hours per ton shipped. The plant total is currently averaging approximately 27 manhours per 100 tons. Table IV shows the current electrical inspector hours per 100 tons produced for the various assigned maintenance areas.

Since the electrical department is responsible for all electrical maintenance, including electric cranes, it has been found most economical for that department to train, assign, and supervise crane operators on a plant-wide basis. One foreman is in charge of this work. The most difficult supervisory job is to meet mill operating requirements, keep within a 40-hour work schedule for each crane operator, accomplish this within the restrictions of a plant-wide seniority unit, and meet operating schedules that vary from mill to mill and from week to week. The crane section consists of 204 crane operators, and these have been scheduled to meet mill operating requirements with a minimum of operator overtime. An average daily force of 176 operators is needed to man mill cranes. It has rarely been necessary either to double over a crane operator or to schedule a man for more than 40 hours a week, even though operating department schedules may vary from five to 21 turns. This program of plant-wide crane operator supervision did not originally meet with whole-hearted support from operating supervision. Most of the anticipated difficulties have been worked out satisfactorily through mutual cooperation, and at the present time, it is felt to be the most satisfactory arrangement by all concerned.

Both mechanical and electrical maintenance of overhead cranes is under the jurisdiction of the electrical department, and a crane millwright foreman and assistant foreman supervise the inspection and maintenance of all overhead cranes. This has made possible a preventive maintenance program that has resulted in a minimum of delays to operations at a minimum of expense. This preventive maintenance program consists of a system of daily reports on crane condition by crane operators, weekly and monthly inspection by crane millwrights, both of which are used to schedule necessary repairs to prevent major breakdowns.

The electrical department supervises all electrical construction in the plant. This work is carried out under the direct supervision of the superintendent of the department and his assistant, working through the construction crew mentioned previously. This crew is composed of approximately 20 electrician linemen, wiremen, and helpers. It is necessary to include linemen in the force, since the plant is located in an area of high electrical disturbances and most lines are carried on overhead structures.

In the case of new construction that is performed by outside contractors, the work is coordinated and supervised through the electrical department organization. Frequently, as pointed out previously, the inspector foreman who will be responsible for the maintenance of new equipment carries a portion of the responsibility of following the contractor's work. In any event, such work is watched closely by the superintendent and his assistant. Since the department has been concerned with the project since its initiation, it is familiar with the design, equipment specifications, and the work the equipment will be required to do, so that this responsibility does not become an inordinate burden.

One of the major problems encountered in any maintenance work is the training of new employees. The traditional methods of employee training have been changed by requirements of labor agreements. The establishment of union representation at Pueblo has been turned to an advantage for the training of craftsmen and electrical maintenance personnel. The wage rate inequity program has resulted in a clear-cut definition of rates of pay and skills required, and has eliminated many difficulties that were previously encountered in the assignment and compensation of maintenance personnel.

An apprenticeship training program has been established for armature winders, electrician linemen, and electrician wiremen. This program consists of related correspondence courses and the following tabulated hours of on-the-job training:

Armature winders	7,280 hours
Electrician wiremen	8,320 hours
Electrician linemen	6,240 hours

This program is co-ordinated through the industrial relations department and the United Steelworkers of America, and utilizes to the greatest extent possible, federal, state, and local educational facilities and agencies. To date, seven armature winders, one electrician wireman, and two electrician linemen have been trained. It has resulted in a well trained and well balanced electrical craftsman force. No trained craftsman has left the electrical department since the inception of this program.

Electrical inspectors are trained on the job. Promotional policy within the electrical department stipulates that only qualified helpers may be promoted to electrical inspectors. A plant-wide seniority unit enables this policy to be carried out without conflict. Actual experience has demonstrated that normally senior inspector helpers are the ones promoted to vacancies, but these promotions are not made on a turn-to-turn basis. Rather, when an electrical inspector helper has demonstrated his qualifications, he is promoted to a regular assignment as an electrical inspector, provided the need exists for such an assignment. This policy has not resulted in seniority grievances due to the policy in the electrical department of straight-forward dealing with the employees and adherence to strict rules on ability.

It should be added to what has been said previously that the electrical department performs its function with a minimum of paper and overhead work. The office force consists of an electrical department practice man and two clerks in the superintendent's office. Each foreman is responsible for scheduling his own work, and any necessary coordination is handled through the superintendent or his assistant. It has not been necessary to establish a formal work scheduling system to supplement the knowledge and experience of the foremen involved. Man scheduling for the department is performed in the superintendent's office. This has been the result of the plant-wide seniority unit, so that centralized scheduling is necessary to eliminate overtime and unnecessary labor-management disputes.

No drafting or engineering is performed in the electrical department. Necessary drawings are prepared in the design engineering department as the requirements are determined in the field.

The key to the efficient operation of this department in an integrated steel mill, covering a large area and including all types of electrical equipment, has been the selection of experienced and competent supervision. A program of strict qualifications of workmen prior to their promotion, an integrated training program, and straight-forward dealing with employees has resulted in the development of a supervisory force within the department with a proven capacity for leadership and ability to co-ordinate their own efforts with the efforts of others. With only two exceptions, the supervision in the department has been developed through this policy, and it has been necessary to supplement the organization only when trained electrical engineers were required. Therefore, being able to develop a hard-hitting, compact organization that is not a "degree" team, in this day of rapid engineering and technological changes, has been a major accomplishment at the Pueblo plant.

DISCUSSION

PRESENTED BY

M. J. WOHLGEMUTH, Manager, Electric Service, Service Department, Apparatus Division, Westinghouse Electric Corp., East Pittsburgh, Pa.

E. F. DONATIC, General Superintendent, Kaiser Steel Corp., Fontana, Calif.

FRANK O. PHILLIPS, Assistant to Vice President, Steel Maintenance Engineering, United States Steel Corp., Pittsburgh, Pa.

HAROLD E. WATSON, Electrical Superintendent, The Colorado Fuel & Iron Corp., Pueblo, Colo.

G. M. KYLE, Assistant Superintendent, Electrical Dept., Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

JOHN F. KOSTELAC, Assistant Electrical Superintendent, Crucible Steel Co. of America, Midland Works, Midland, Pa.

M. J. Wohlgemuth: I am somewhat surprised to read that no outside help is required in making repairs, especially to large equipment. Apparently, there has not been any major failures of their large rotating equipment. A shop, such as the one at Peublo, can lift coils and reinsulate, but I believe that in case of a complete failure of an armature of a large d-c machine or of a stator of a large a-c machine, that the shop facilities could not manage the manufacture and processing of the coils needed. The force available for winding (16 men) is probably adequate to handle a rewind on a large machine, but I still feel that supervision by an engineer from the manufacturer would be most helpful.

I am also somewhat surprised at the policy of not utilizing graduate engineers. It would seem to me that in this age of complex control equipments that some technical trained engineers should be invaluable in solving problems that arise. Unless the engineering department can supply such technical assistance as required by the maintenance department, I would expect some problems would be presented that would be difficult of solution without calling in manufacturer's engineers.

The practice of having maintenance people present during installation and start-up of a new equipment is an excellent one and could be followed with well-earned results by a large number of companies who do not have such practices. The experience at Pueblo certainly bears out the benefits that can be obtained.

While details are not given, I have the impression that records were not kept of individual pieces of equipment. I am referring to a case history card or file which records all of the operations performed on the apparatus from the time it is installed until it is scrapped. Records such as this, I feel, are invaluable in pointing out recurring troubles which can be analyzed and corrective measures taken. It would show for instance that a certain motor was in the shop for rewind too often and checks could be made that might indicate that a different type of motor or that a larger motor would be desirable.

I believe that Mr. Watson should be complimented on his presentation and I hope that this discussion will be taken in the spirit that it is given—that is to be helpful.

E. F. Donatic: As our steel plants grow larger, our concept of organization and maintenance changes. We at Fontana have centralized electrical and mechanical departments, entirely separate. In our new strip mill we are seriously contemplating combining these two under one supervision due to some of the problems that we have encountered in the past.

As far as training goes, I think training probably is the most important singular thing that we have today in industry. We certainly have plenty of problems in maintenance. Equipment becomes more complex, and some of the people that we get or are forced to use in many of the labor union arrangements that we work under today cannot absorb all the complexities of the equipment that we have to work on, so the training certainly is very necessary.

However, I would like to emphasize that training of operators is always very important, because they can certainly make a lot of work for us on the modern machines that we have in the steel plant.

As far as mixing college engineers with practical men in maintenance, I certainly agree that it is very necessary, but one of the problems that we have encountered in the last few years is that engineers did not seem to want to cope with the every-day industrial relations problems that you encounter in operation, and they would much rather either transfer back to engineering or leave entirely and get into aircraft or industries of that nature. These present rather easy jobs to young engineers today, and at very good salaries, too, because in many cases they are government-financed and salaries are not a particular problem.

I believe that Mr. Watson should be congratulated on the job the electrical department has done at Colorado Fuel & Iron, and I would like to thank him for an excellent paper. He has also touched on many examples, some of which we may use in our own operation.

Frank O. Phillips: I would like to ask Mr. Watson to elaborate on some items briefly as some of the practices used and the organizational setup is quite different from that in the Pittsburgh and Chicago area plants of United States Steel. We have many common problems in maintenance as we too have old plants in many instances as well as new ones, and a combination of both, and have all of the attendant problems of plant maintenance including those in electrical maintenance.

The principal difference in handling maintenance in United States Steel plants as compared to Colorado Fuel & Iron is that our maintenance supervisory organizations are trained and developed to handle both mechanical and electrical maintenance; thus tending to combine plant maintenance under one head rather than separate them into mechanical and electrical organizations.

I would like to ask Mr. Watson the following questions concerning his paper on electrical maintenance.

1. Why is the assigned maintenance and crane operation in the open hearth under the direct control of the open hearth rather than under the electrical superintendent as, I understand, is the case for the balance of the plant?

2. Do you encounter any problems from the operating departments where you have area supervision covering more than one operating unit such as foremen of the 40-in. mill, foundry and pig machine, and are your motor inspectors also assigned to areas covered by the area supervisor or are they assigned to certain operating units within the area?

3. You mentioned in your paper that due to the location of the plant away from any heavily industrialized area your maintenance facilities must be entirely self-sufficient. However, I am somewhat surprised that you rebuild your own high tension coils, such as the 1200-hp, 6600-volt coils mentioned in your paper.

Is it true that you make your own coils or do you stock certain coils for expediting repairs to your motors?

4. You state in your paper that crane operators are trained, assigned, and supervised on a plant-wide basis under one supervisor.

Are your cranemen assigned to certain cranes or certain operating departments or do they work any place in the plant as assigned?

Where do you get new people that you intend to train as cranemen? By this, I mean are they hired directly as cranemen trainees or are they promoted from plant labor forces or from some other promotional sequence.

Harold E. Watson: I will attempt to answer Mr. Phillips' questions as I understand them. Prior to 1926, electrical assigned maintenance and crane operation at the open hearth were supervised and scheduled from the main electrical department. At that time a change was made toward direct departmental control of all maintenance at the open hearth in an effort to obtain more team work from open hearth personnel. There has been no occasion in the meantime to change the organization; however, while actual field maintenance is supervised from the open hearth, all shop work, such as coil rewinding, armature repair, etc., is handled from the main shop. There is no friction in this arrangement.

We have not had any difficulty with a maintenance supervisor covering an area under the jurisdiction of two different operating superintendents or in two different departments.

We do wind coils of any size or voltage as may be required for plant maintenance. We do rewind and rebuild electrical components for stock and do not purchase coils. We replace them as required.

Our cranemen are assigned to cranes as required by plant operation, the ability of the craneman, and the crane to which his seniority may entitle him. Under certain types of operation, however, where there are two cranes in one bay and only one man assigned, that man then becomes assigned to the area. If there is trouble, and if the equipment on one is different from the other, we move from crane to crane in that one bay, and we have had no difficulty.

In the electrical department, we hire everyone from the gate. We have no labor pool in our own department nor do we have a plant-wide labor pool from which men must be promoted. We question and examine the person the employment office sends us. If he does not appear to be suitable for employment in the electrical unit, we reject him.

G. M. Kyle: Mr. Watson has presented us with a very clear picture of the organization and responsibilities of the electrical department at the Pueblo plant of C. F. & I. With the exception of the assigned

maintenance divisions at the open hearth, it is a typical centralized maintenance organization of an integrated plant. I would like to comment specifically on three points in this paper.

1. Mr. Watson indicated that very close co-operation is required between the engineering, electrical, and mechanical departments when developing designs and layouts of new equipment or facilities. We, too, at Inland, firmly believe in that practice. Obviously if the maintenance supervisor is to be held responsible for the maintenance of the equipment after it is installed, he should participate in the preparation of specifications of the equipment before it is ordered.

2. Mr. Watson stated that no spares are carried for the major drives. I wish to disagree with this conception. At our plant, we order spares for major units and feel we have ample justification for so doing. The main reason, of course, is to help insure maximum operations by keeping scheduled and unscheduled downtime to a minimum. Also since many of our departments, as in most integrated mills, are dependent upon the product furnished them by the preceding department, a major delay in one department can also affect the operations of the next department.

In addition, as part of our preventive maintenance program, we have a varnish schedule, which means that all major units are dismantled, cleaned, varnished, and reassembled approximately every three years. We feel that such a program has proven to be sound since insulation failures and other maintenance difficulties have been kept to a minimum over the years. The fact that we have spare units enables us to schedule such work in a shorter time than if we had no spares. For example, some major units are handled on the varnish schedule in four turns. If we had no spare generator armature for a certain department, this time could be lengthened to five or six turns, or more.

The fact that we maintain spares for major drives does not mean we have a spare for every unit. Whenever we purchase a spare unit for a main drive, the other drives in the plant that are similar to or identical to this unit are closely scrutinized, and with due recognition to design improvements, the spare is made interchangeable with as many other units as possible.

3. Mr. Watson also recognizes the all important phase of training. I was particularly interested in one comment, namely, that the journeymen apprentice program is coordinated between the industrial relations department and the United Steel Workers of America. I would like to ask Mr. Watson if he would kindly elaborate on this point.

Harold E. Watson: We have a joint committee of company and union members on the apprenticeship selection committee who screen all applicants. All applicants are then given aptitude tests and the results of these tests, in conjunction with previous training and experience, determine the placement of the applicant in a particular craft. In so far as possible, this placement is in line with the wishes of the applicant.

Each craft has a union member particularly assigned to co-ordinate and assist in the training of the apprentices, and management has an apprentice supervisor responsible for setting up the training program and following the progress of each apprentice through his entire training period.

Our apprentice program, which consists of both shop work and supplemental correspondence course material, has worked very successfully in giving adequate, well-rounded training and experience to our apprentices.

The joint committee relationship has been highly successful and amicable relations have always been maintained.

John F. Kostelac: Mr. Watson, has any attempt been made to set up an apprentice program for the first six job classifications leading to a motor inspector helper? I understand you have a craft training program.

I feel a motor inspector helper must be trained and must gain experience to successfully analyze electrical troubles on present day and future mill control equipment. With the advance of automation, it is apparent that within the next ten years, electrical maintenance personnel may have to be technicians. The seamless tube mill at your plant may be a "punch-card" operation tomorrow. How and where would you get men to handle such a mill?

One solution is to work into the craft training program, a training program for the non-craft motor inspector helpers up to job class six—call this an orientation program if you wish. When helpers are required for various areas throughout the mill, the men can be selected from the trained grouped rather than an ordinary labor pool. Training and experience can be given to the men to fit future demands.

What is your thought in regard to the use of technicians to do trouble shooting on complex control schemes and use motor inspector helpers to change equipment, motors, contactors, etc., as required?

Also, has anything been done on considering the possibility of technicians that will do trouble-shooting on control and let helpers just change the equipment?

Harold E. Watson: Helpers are assigned to all departments and with different inspectors throughout their training period. Training, therefore, is accomplished by actual field work on all of our diversified equipment under the direct supervision of the inspector foreman and indirect supervision of the electrical inspector.

We urge all of our men to attend our local junior college, if possible, and give all the help we can to those interested. Many of our men take correspondence courses and seek our advice on their choice of subjects.

We attempted to set up a training program under the Smith-Hughes Act and furnished instructors, but the enthusiasm that greeted its inception quickly waned and attendance fell off until it became necessary to discontinue the program.

Our training methods, which have proved to be adequate in the past, undoubtedly will require revision as automation continues to progress into our plant. Electrical inspectors will, as you say, be supplanted by technicians, and their training will become a problem to be solved either by setting up our own training program or by raising the educational requirements of our helpers when they are hired.

It should be pointed out that electrical inspector helpers may be assigned at management's discretion, to any area within the plant without regard to their own desires or to seniority, and are not promoted to electrical inspectors until from management's point of view they are fully qualified. This practice enables management to thoroughly train helpers before they are promoted.

MEN AND MILLS

By R. L. GRAY
President
Armco Steel Corp.
Middletown, Ohio

. . . paper presented at the informal stag dinner at the 1957 Annual Spring Meeting held in Cincinnati, Ohio on April 30, 1957. . . .

▲ MAKING and rolling steel are fascinating topics but there is one element in our business—and our lives—that is even more interesting.

That is people.

People make our business, or, putting it another way, our business is really people.

WHY GOOD EMPLOYEE RELATIONS ARE IMPORTANT

The mills of the steel industry today are certainly in fine shape. In the years since World War II, our industry has had a thorough face-lifting. About $9,000,000,000 has been spent to improve older facilities and build new ones. The manufacturers of steel mill equipment have turned out some really amazing machinery that will do some very difficult jobs. We certainly ought to be making steel much more efficiently now than when we had to hold the old mill together with baling wire—and I think we are.

Yet the most modern and efficient equipment and the buildings to house it would be totally valueless without people. We must have skilled, interested men to use these tools efficiently to make a product the world needs. Without human direction, machines are utterly worthless.

Let us use our imagination for a moment to try to really get to the heart of this thing.

There are about 650,000 people here in America today engaged in the business of making steel. Try to imagine what it would be like if those 650,000 people suddenly vanished off the face of the earth and tomorrow morning we were faced with the job of keeping production going as usual.

The steel industry would come to a sudden, jarring stop. The plants and facilities would all still be there, and in time we could employ 650,000 new people to operate the furnaces and mills. But it is anyone's guess as to how long it would take to develop enough skill and knowledge in these new people to get the wheels rolling again. And how many years would it take to get efficiency built up again to its present level?

Hydrogen bombs notwithstanding, I do not think we are ever going to be faced with such a problem.

But turning back to the situation at hand and the problems we meet every day, we can ask ourselves this question: "How much more efficient could our production be if every single man in the plant was putting forth 100 per cent of his energy and ability on his job every day?"

It is in this area that the talent of industrial management is actually measured. Management has control over only a small fraction of the company's dollar. We must pay the going price for raw materials. We have no control over taxes and very little over the interest charges we must pay on borrowed capital. Wage rates and employee benefits are much the same throughout the steel industry. Management is surrounded by fixed obligations and this is true of most companies.

Yet, there is one area which offers management broad opportunities. This is the handling of people.

Management's ability, to create conditions which encourage people to work together and more effectively use the physical facilities of the company, offers a real opportunity to cut costs and to forge ahead of competitors.

Good employee relations, then, have a definite dollars-and-cents value, and deserve all the attention we can give them. They can give us greater efficiency through: (1) fewer mistakes and better satisfied customers, (2) lower absenteeism, (3) greater loyalty, (4) fewer grievances, (5) lower turnover, and (6) fewer work stoppages.

APPROACHING THE HUMAN RELATIONS PROBLEM

I would like to make a few observations and reflections about the question of employee relations gained during some 40 years in the steel business.

The conduct of human relations is the biggest job we have today. In the areas of technology and production, we have made giant strides, especially in the past 15 years.

Technology has now carried us far beyond the imagination of the average man. Here in America we no longer face the question of how to produce enough goods and services to provide for all of our citizens. We are doing a masterful job of operating and improving our physical facilities.

We have not been doing as expert a job, however, in dealing with people.

We have extensive personnel departments set up to advise us on how best to conduct our employee relations. Today, almost everyone in the steel industry has a long list of so-called "fringe" benefits, costing his company 29 cents an hour or more.

These benefits, of course, are in addition to the highest wage scale in the history of our industry.

But are all these things enough to provide real, deep-down satisfaction in our employees? Apparently they are not, for we continue to have strikes and labor disturbances of all kinds.

So we ask ourselves, "What is wrong? What does it take?"

Some of the surveys of employee opinion that are being made these days can tell us some of the answers.

We do not have to dig too deeply into the thinking of our employees before we encounter some hostile attitudes. We find outlooks which we consider unreasonable. We find ignorance of the economic facts of life as we know them.

It is hard, sometimes, for us to understand how some of these misconceptions exist. We know that the great majority of our employees are intelligent, reasonable people.

Yet, if we are going to make any progress in human relations, we have to accept hostile attitudes and unreasonable viewpoints as being sincere convictions. We cannot just laugh them off.

COMMUNICATIONS

We are smart enough to build bridges across the Mississippi River, Chesapeake Bay, and now the Straits of Mackinac. We seem unable to bridge the chasm that often exists between the company and the man.

Our opinion surveys tell us—though it is sometimes hard for us to believe—that management news has better employee acceptance than news from union sources.

This fact does not discourage the union representative one bit, however. He just works all the harder to transmit his version of the story.

Unfortunately, some union leaders do not confine themselves to selling the benefits of union membership, but attempt to discredit the company and its management. Too often they paint a lurid, inaccurate picture of how employees are overworked and short changed in order to make employees dissatisfied. If they are successful, the result is that production is impaired.

It is beyond question that this kind of activity is not in the best interests of the employee. Anything that weakens the company's ability to operate efficiently and meet its competition will hurt the employee in the long run.

Actually, of course, the union prospers as the company prospers. There is only one source of union dues—men with jobs. Destructive practices which weaken a company's ability to compete represent a real threat to security of the employee's pay check and to some extent to the union's own income. Some union leaders now recognize this and are using more constructive policies. Ultimately, most of them will come to this realization.

Until that day arrives we must work doubly hard. This business of communications runs in two directions. The content of the thoughts we communicate to our men should be determined to a large extent by what we learn from their communications to us relayed through their supervisors.

For instance, the most common complaint of industrial workers is that management is interested more in profits than in people. You and I know very well that a company which does not earn a profit is not a good company to work for. Our men should be shown how they are benefited by profits.

Years ago, management thought it dangerous to give out information about the business. But that viewpoint has changed greatly in the past 25 years.

We have learned that there can be few corporate secrets. Somehow the news always seems to leak out. We are realizing that it is much better to have information on profits, costs, expansion, and other subjects vital to the business and the employees presented accurately by management. If we do not present them clearly, the employee is often likely to hear only a twisted version via the grapevine, while rumors begin to drive a wedge between management and men.

We cannot expect our people to make sound decisions unless they currently have proper information on which to make those decisions. And the man on the job will not get this information unless we make it available through a planned program and hard work.

THE IMPORTANCE OF FOREMEN

In building and maintaining good employee relations there is one man whose importance management recognizes but sometimes neglects to give the proper support.

In the day-to-day business of making steel, we are really in the hands of our foremen. For 16 hours each day they take over and run the plant. The works manager, the superintendents, the engineers, the employee relations men, all the staff men have gone home. The foreman is boss.

How he handles the human relations problems he faces is what really determines the attitudes of our employees.

The big boss could make a speech on good human relations twice each day. So could the vice presidents and all the other brass. But the foreman is the man who really counts. If he plays favorites, or does any of the other things he is sometimes accused of, all the speeches in the world will not build good employee attitudes.

Most foremen are outstanding men. They were chosen for their positions because they had something extra. We need to take full advantage of their ability.

It is my candid opinion that foremen generally want to do a good job. When the foreman makes a mistake, it is usually because he has not been told or does not understand what management wants him to do.

As industry has become more complex and departmentalized, I have noticed a tendency among foremen to depend upon staff departments more and more. For example, there is the growing inclination to let the personnel department worry about employee relations. This just will not work. No matter how outstanding a personnel department we may have, the foreman cannot surrender his responsibilities. He must always be the front line personnel man if we expect to have good relations with employees.

Sometimes we short circuit our foremen, particularly in the field of contract negotiations. We do not keep them informed as we should, and they get their information about the company from the union, the newspapers, or from the old grapevine.

This certainly lowers their prestige in the eyes of their men. The employees see that their foremen have been ignored and naturally think that they are not important. The employees' attitudes toward their foremen are formed accordingly.

Our foremen need to be reminded, frequently, that communicating facts about the company to employees is one of their major responsibilities. Some of them do not realize this.

Once our foremen recognize this responsibility, then we must make sure they regularly get the information they need.

We are making some real progress in this direction. Many companies now prepare management newsletters for their foremen and are making other efforts to help foremen to carry out fully their role as managers. Quite a few other companies are distributing newsletters to their entire employee organization.

We have more work to do in this area.

Perhaps some of our communications may not be properly aimed. But with a little more practice we can become expert riflemen.

EVERY JOB IS IMPORTANT

One of the most important phases of human relations in an industrial plant has to do with human dignity. That is an elaborate way of saying that people like to feel that the work they are doing has significance, that it is important.

The average employee will give his best efforts willingly if he feels that what he is doing is important and that his work is appreciated.

Perhaps some time in your career you have had the experience of working for a boss who made you feel that your work was about as important as the office boy's. He may not have said that in so many words. But that was the impression you got from him and you can probably recall how you acted. Very likely it was hard to pull out all the stops and do your best work.

"If it is not important, what is the difference how well I do the work," you may have said to yourself. "I will do just enough to get by."

We do not need a psychologist to tell us that a workman in a steel plant has far greater difficulty in understanding the importance of his job than a technician with management ambitions.

The man who is feeding a temper mill, inspecting sheets, or doing any one of the hundreds of repetitive jobs we have in all our plants does not have a very broad horizon in front of him.

It is difficult for him to see past his own job. He does not understand how his work is related to other operations. He may not realize that if he makes a mistake the result may be a dissatisfied customer or the scrapping of material in which the company has already invested a good many dollars by the time it gets to him.

This feeling that the job he is doing is not important is not always restricted to the man in overalls. In recent years the shortage of engineers and scientists has caused industry to take a long look at the area of technical education.

One of the interesting facts such studies disclose is that the same feeling exists in many engineering and technical staff departments. Many highly educated people in such positions say that they do not feel like giving their best efforts to their work because they do not see that it is very important.

There are no magic formulas for convincing people that the work they do is an important segment of the overall industrial job. But we can do a great deal about the problem if we seriously feel it is worth the effort.

Some of the employee relations experts have proposed a solution with which I heartily agree. I have seen it work. Their solution is—and I quote—"To generate a feeling of participation." As I interpret it, this means making one feel that he is "in the know," that his work is appreciated and important. One of the many devices they recommend to accomplish this is for managers to ask the employee for advice on problems related to the job. Did this ever happen to you in your early years? If it did, I will venture that you were highly complimented. Perhaps you even went home and told your wife that "the boss asked my advice today."

WIVES CAN HELP

Speaking of the wife reminds me of another aid to good employee relations.

Whether we recognize it or not, the wives of our employees play a leading role in shaping the attitudes of their husbands toward the company.

The wife wants to see her husband promoted to a better job. She is interested in security. She is vitally interested in seeing that paycheck come in regularly every week. She does not like strikes or trouble. She does not want her husband to get hurt. She is greatly concerned with life insurance, surgical and hospitalization insurance and other family protection benefits. As a rule she is also the more conservative member of the family and often exercises a restraining influence on the head of the household.

So it is not to our credit that we generally do a pretty poor job of selling employee benefits to wives. Nor does management give sufficient recognition to the importance of this member of the family team.

Most companies have employee publications that could be used to do this job, but they seldom are.

Industry has powerful potential allies in the wives of its employees. We should aim more of our communications in their direction.

PUBLISHED POLICIES ARE VALUABLE

One of the most valuable aids to the creation and maintenance of good relations with employees is for a company to write and publish its policies and distribute them to its people and the public.

In saying this, I am referring to the principles and ideals for which the company stands—the philosophy of its management, in other words. I do not mean practices or procedures for carrying out details.

Of course, most companies have policies to guide their relations with employees, and some of them have very good relations. But company policies are most helpful when they are written and published. Then they are constant—they are not likely to change even though the structure of executive management changes. They serve as a guide to all members of the management family and their day-to-day decisions, most of which affect people, are more considerate and consistent.

In addition, published policies give personality and character to the company. When sincere and persistent efforts are made by management to insure that the spirit of the policies is carried out, they generate confidence and faith.

It is encouraging to know that other companies agree with the opinion I have expressed. Three steel firms have recently published policy statements, and I am told that several others are considering doing so.

economics of oxygen generating stations for STEEL MILL HIGH AND LOW PURITY

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▲ We are all aware of the tremendous impact of low cost oxygen on the steel industry today. Oxygen in unlimited quantities is available to industry from on-location air separators which remove oxygen from the air by liquefaction and distillation. With the advent of this low cost oxygen, long known applications in the steel and chemical industries have become, largely since World War II, a reality.

Large quantities of low cost oxygen are of importance to the steel industry at the present time in view of the immediate need to expand iron and steelmaking capacity with a minimum capital outlay. In steelmaking, the use of oxygen provides higher temperatures and a higher rate of refining iron and steel, and thereby permits increased output from existing facilities. On-location generators are presently providing low cost oxygen for the following purposes: air enrichment to blast furnaces, the new top-blown oxygen converter, decarburization in open hearths by means of roof lances, and open hearth combustion. Oxygen consumption for these purposes is certain to expand in the immediate future because of the urgent requirement for increased iron and steel production.

The technology of these and other uses for oxygen were originally conceived and made practical by steel mill engineers and operating personnel. Many articles have appeared lately concerning various applications of oxygen in steel manufacturing, covering such subjects as: (1) the use of oxygen for scarfing and cutting operations in steel mills; (2) the use of oxygen in roof lances to reduce carbon in open hearth furnaces; (3) the use of oxygen for enriching air to blast furnaces; and (4) the new top-blown oxygen converter process.

These and other papers serve to illustrate the importance of oxygen in steelmaking. This importance is further confirmed by the experimental and practical oxygen programs being developed by individual steel firms.

Based on the experience gained while working with steel mill engineers and production personnel in planning, installing, and operating oxygen generating equipment for the various applications in the steel industry, we would like to discuss the several different types of generating stations. We have grouped the major applications of oxygen into four general classifications. The generating and storage equipment selected in each case, from scarfing use to blast furnace air enrichment has been considered from the standpoint of reliability of supply, maximum economy, and flexibility of the generating station.

Case I—This describes a generating station furnishing high purity (99.5 per cent) oxygen for critical requirements such as machine and hand scarfing, welding and cutting, and possibly for decarburization. Depending on the size and type of steel mill, the total oxygen consumption is usually between 5 and 100 tons per day. This classification of oxygen usage has been so integrated into steel production, that most mills today would be seriously handicapped without a continuous supply of high purity oxygen. Because of the critical nature of these requirements, absolute continuity of supply is provided by the installation of multiple generators.

Figure 1 shows an installation comprised of four identical and independent generators, each capable of producing 7000 cfhr (or 7 tons per day) of 99.5 per cent oxygen. This station has a capacity of 28 tons per day or 20,000,000 cu ft per month. Generators of this type are factory assembled and range in capacity from $^3/_4$ up to 25 tons per day. Although oxygen is generally required for pipeline distribution at about 165 psig, oxygen is delivered from the generators at pressures up to 2400 psig for charging into high pressure gaseous storage tubes and into portable cylinders. Gaseous oxygen storage is provided for two reasons: first, to serve as a receiver to furnish peak demands, and second, to serve as a standby source of oxygen when one generator is shut down for maintenance or defrosting. The flow of oxygen from the generators to storage and to the pipeline is automatically controlled by the pressure control panel.

Figure 1 also illustrates the typical high purity oxygen consumption curve in a steel mill. When the pipeline demand is less than the total output of the generators, the balance of production is automatically charged into storage. When the pipeline demand is greater than the

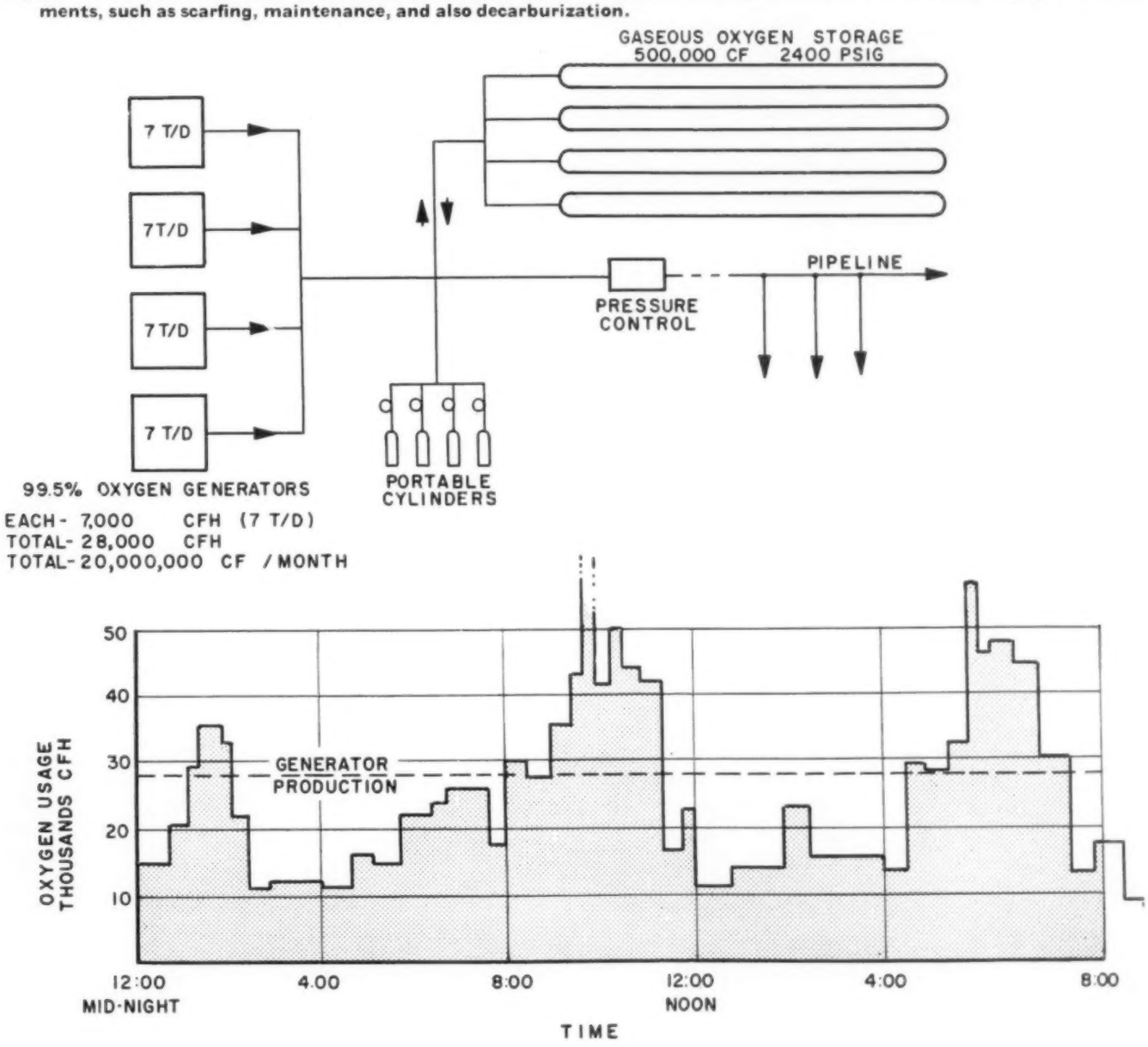
. . . . under present conditions, costs for oxygen will run from $5 per ton up to $26 per ton depending on the demand, purity and continuity of operations which are required . . . .

OXYGEN APPLICATIONS

oxygen producing capacity, the balance is supplied from storage. The number and capacity of generators and the volume of storage for a given installation are designed to meet the user's most severe peak oxygen demands and to furnish oxygen continuously when one unit is shut down. This system is very flexible in that one or more generators may be easily shut down or started, depending on the volume of oxygen in the storage bank and the rate of consumption.

Figure 2 shows a Case I installation in a fully integrated steel mill. This installation consists of four generators, including three 12-ton per day units and one

Figure 1—The Case I installation consists of multiple high purity oxygen generators for furnishing critical oxygen requirements, such as scarfing, maintenance, and also decarburization.



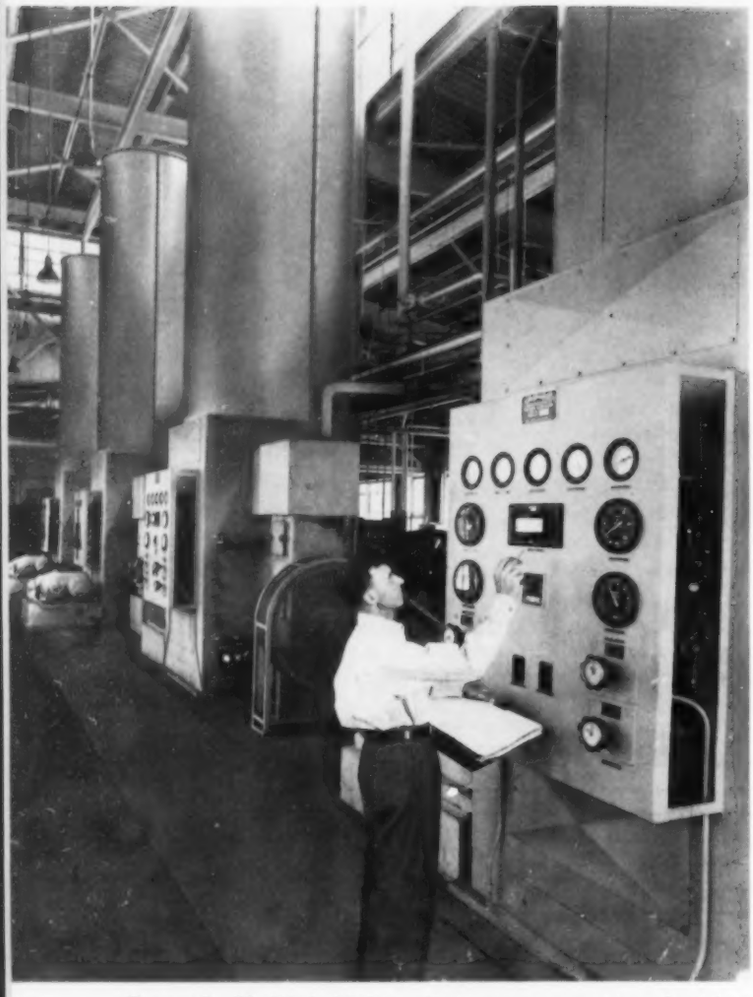


Figure 2—Multiple high purity oxygen generator plant in a steel mill, consists of three 12-ton per day and one 6.5-ton per day generators.

6.5-ton per day unit plus 500,000 cu ft of oxygen storage. This generating station furnishes oxygen for critical applications, including automatic hot scarfing, hand scarfing, welding, cutting, and steel fabrication. In addition, about 200 portable oxygen cylinders per day are filled for use at locations not supplied by the main distribution pipeline. Figure 2 shows the four distillation columns and their control panels. The air compressors and auxiliaries are located directly behind the distillation columns. The charging manifold and loading dock for portable cylinders are located in a 20-ft bay at the opposite end of the building.

Case II—This describes a generating station furnishing high purity oxygen for critical requirements such as scarfing and routine uses as discussed in Case I. It also furnishes large volumes of high purity oxygen on a continuous basis for a critical tonnage oxygen requirement such as oxygen for top-blown converters. The converter blowing cycle is performed in about 38 to 45 minutes and, with multiple converter vessels, it is expected that the process will be continuous. Therefore, this is another case where oxygen supply is critical and cannot be interrupted.

Figure 3 illustrates an installation comprised of two identical and independent generators, each capable of producing 115,000 cfhr or 115 tons per day of high purity 99.5 per cent oxygen. In addition, gaseous and liquid storage are provided. The gaseous storage serves as a receiver to balance the user's variable consumption with the predetermined production rate of the generators. The liquid storage provides a standby source of oxygen for use when one of the generators is shut down for maintenance or defrosting. In Case II, liquid oxygen storage is employed because of its economy when a large volume is required. The liquid storage is filled from a side stream of liquid oxygen withdrawn from the two generators during normal operation. Each generator is also equipped with oxygen pumping equipment to deliver a side stream of gaseous oxygen at pressures up to 2400 psig for charging into portable cylinders.

Figure 3 also illustrates the typical oxygen consumption curve for a mill employing top-blown converters. The curve shows the oxygen-on, oxygen-off characteristic of the converter blowing cycle. Superimposed on this block type curve are the smaller peaks and valleys which represent the normal routine oxygen uses.

Considering present oxygen converter vessel sizes and expected annual steel tonnages, oxygen generating stations in this second category range in size from approximately 100 to 400 tons per day capacity. Case II oxygen generating stations are also applicable for those steel manufacturers with open hearth combustion oxygen requirements who require continuity of supply.

Case III—This case describes a generating station furnishing high purity oxygen for critical requirements such as scarfing and routine uses as in Cases I and II. It also provides large volumes of high purity oxygen for a semicritical tonnage requirement, such as for open hearth combustion or for roof-lances. These generally do not require the degree of continuity as in Case II. For this application, the steel manufacturer is willing to forego oxygen usage in the open hearth during the time when the large capacity generator is shut down for maintenance or defrost. He decides that the slight loss in steel production through longer open hearth heat times when the tonnage generator is shut down does not justify the additional expense for providing the features of a continuous oxygen supply system as in Case II.

Figure 4 illustrates a Case III installation comprised of a single tonnage generator, capable of producing 150,000 cfhr or 150 tons per day of 99.5 per cent oxygen. During normal operation, this generator furnishes the tonnage oxygen for the semi-critical combustion requirement and also furnishes oxygen for the critical steel mill requirements.

It should be mentioned here that, for open hearth applications, while oxygen at purities of less than 99.5 per cent can be used, it is preferable to generate all high purity oxygen to increase flexibility and to eliminate the need for two separate pipeline distribution systems. Our experience indicates that there is about 5 to 8 per cent increase in capital cost for a generator capable of producing 99.5 per cent oxygen under pressure, as compared with a generator producing 95 per cent oxygen. This increase in capital cost amounts to a 3 to 4 per cent increase in total oxygen cost since producing costs are about the same in either case.

The generator illustrated in Figure 4 also produces a side stream of liquid oxygen, which is used to fill the standby liquid storage system. When the tonnage gener-

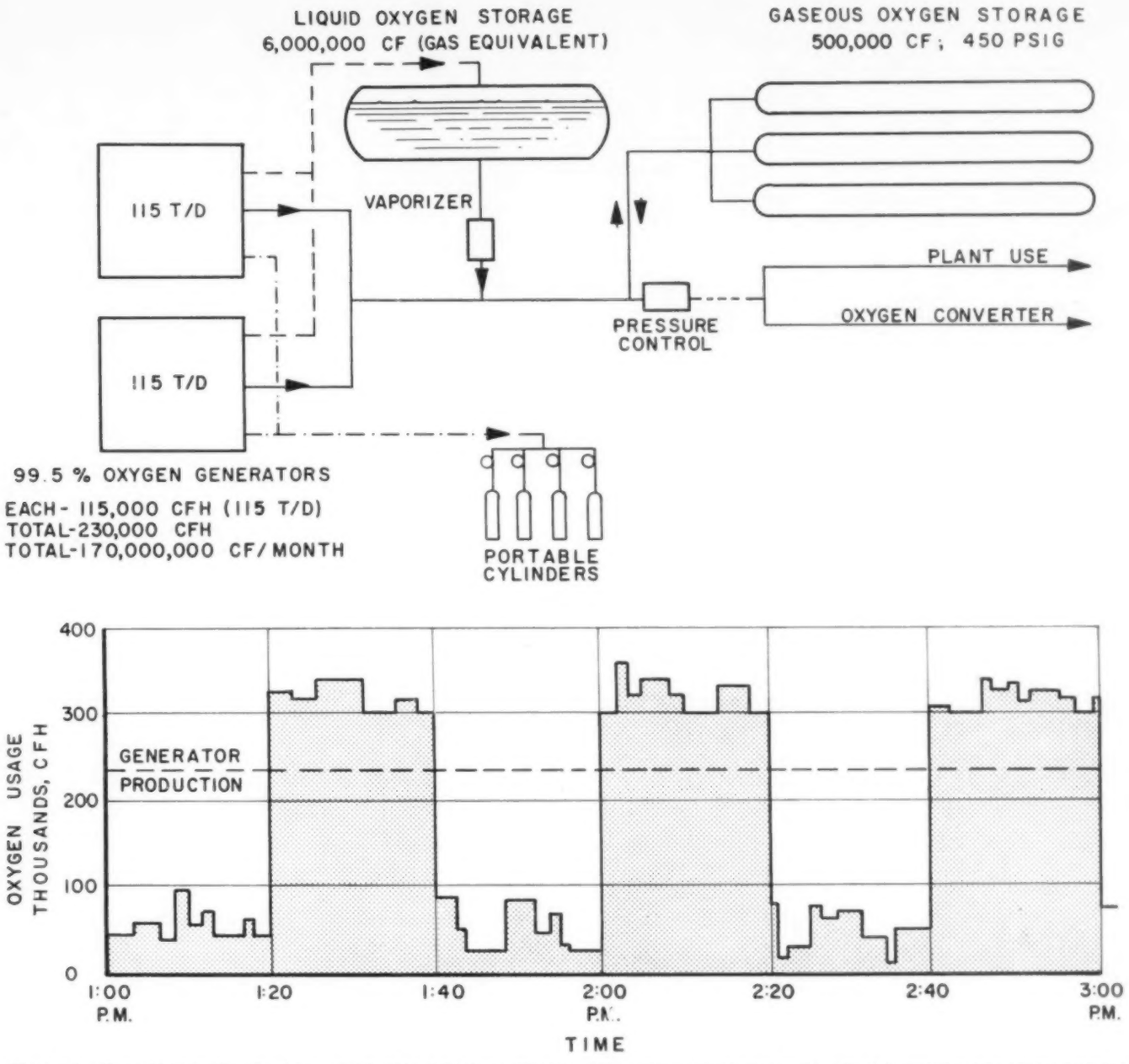


Figure 3—Case II installation has two identical high purity tonnage oxygen generators plus liquid oxygen storage to supply oxygen during generator shutdown, and gaseous oxygen storage to furnish peak requirements.

ator is shut down for maintenance or defrost, the large volume of liquid oxygen is vaporized to supply the critical steel mill requirements. Medium pressure gaseous storage is provided to balance the varying usage with a predetermined rate of oxygen production. This generator is also equipped with a liquid oxygen pumping system for filling portable cylinders.

Case III installations range in capacity from approximately 100 tons per day to 400 tons per day. This type of generating station can also be employed to furnish oxygen for a mill with top-blown converters if the converter process is on an intermittent basis.

Figure 5 shows a typical tonnage oxygen generator with the cold box located outdoors. The cold box contains the distillation column and the regenerators or heat exchangers. The main air compressor is located directly behind the cold box in the corrugated metal building. In the foreground can be seen the two vertically mounted centrifugal liquid oxygen pumps and the two electrically loaded centrifugal expansion engines. A refinement of the installation shown is an arrangement whereby the liquid oxygen pumps and expanders are located adjacent to the cold box but inside the air compressor building for better accessibility.

The liquid oxygen pumps are a part of our cycle whereby the oxygen is put under pressure as a liquid, passed through heat exchangers where its refrigeration is given up to the warm incoming air and emerges from the plant in usable form as a compressed gas. This cycle is employed in the generators described in Cases I, II, and III.

Case IV—Here is described a generating station furnishing high purity oxygen for critical requirements as in Cases I, II, and III. It also furnishes tonnage volumes of low purity (95 to 98 per cent) oxygen for a noncritical requirement which does not require a standby source of oxygen. One example of this application is

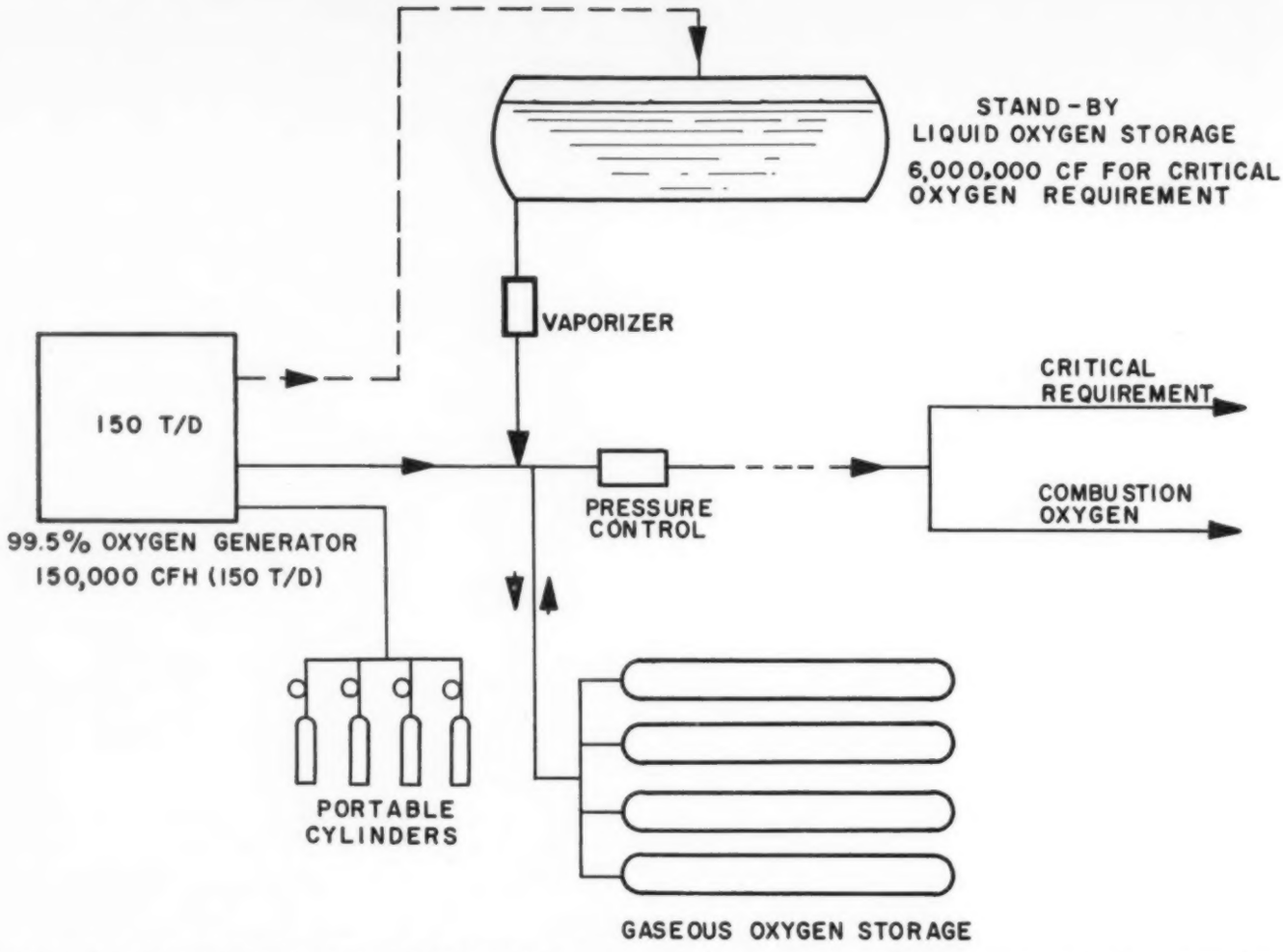


Figure 4—Case III installation has single high purity tonnage oxygen generator for critical and semi-critical oxygen requirements, and liquid oxygen storage for furnishing critical requirements when tonnage generator is down for maintenance.

oxygen for air enrichment to blast furnaces for pig iron production. In this case, when the tonnage generator is shut down for defrosting and maintenance, the blast furnaces continue to operate using normal air. Another example of this application is oxygen for partial oxidation of hydrocarbons in the production of hydrogen for the H-Iron process. For this application, the oxygen generator can be shut down when the chemical process is out of service for maintenance. In this sense, the requirement for oxygen is not continuous; therefore, noncritical as compared to scarfing oxygen requirements as in Case I.

Figure 6 illustrates a Case IV installation comprised of a single low purity tonnage generator capable of producing 500,000 cfhr or 500 tons per day of 95 per cent oxygen. In this case, the oxygen is supplied at low pressure to the intake of the blast furnace blowers. The critical high purity requirements of the steel mill are also furnished from this station. A side stream of high purity oxygen is withdrawn to take advantage of the low producing costs from the tonnage plant. Tonnage generators can be economically equipped to produce a side stream of high purity oxygen in volumes amounting to 10 or 15 per cent of the total production. If required, an auxiliary high purity generator of the Case I type may be installed to furnish the balance of the steel mill critical requirements. A high pressure gaseous storage bank is provided to balance the varying requirements with the constant output of high purity oxygen from the generator. As in Case III, liquid storage is furnished to supply the critical needs when the generator is down. For the application of oxygen to enrich the air to a ferromanganese blast furnace, additional liquid storage would be provided to supply the necessary oxygen to gradually reduce the blast furnace temperature after the tonnage generator is shut down. The objective of extremely low cost oxygen is achieved for blast furnace use by incorporating the following three factors:

1. A single unit is installed for the tonnage oxygen requirement. This is satisfactory to most users because of the non-critical nature of this application as outlined previously.
2. Because of the large quantity of oxygen for blast furnace use compared with the amount for critical needs, it is preferable to take advantage of the savings by generating low purity oxygen (95 per cent).
3. Additional economy is effected by supplying the oxygen at slightly above atmospheric pressure. This reduces the amount of power required per unit of oxygen produced, as compared with the former cases, wherein oxygen is required under pressure for storage and use. This is acceptable in the case of oxygen supply to the blast furnace since there is no fluctuation of

oxygen usage; therefore, no accumulator or surge capacity is required.

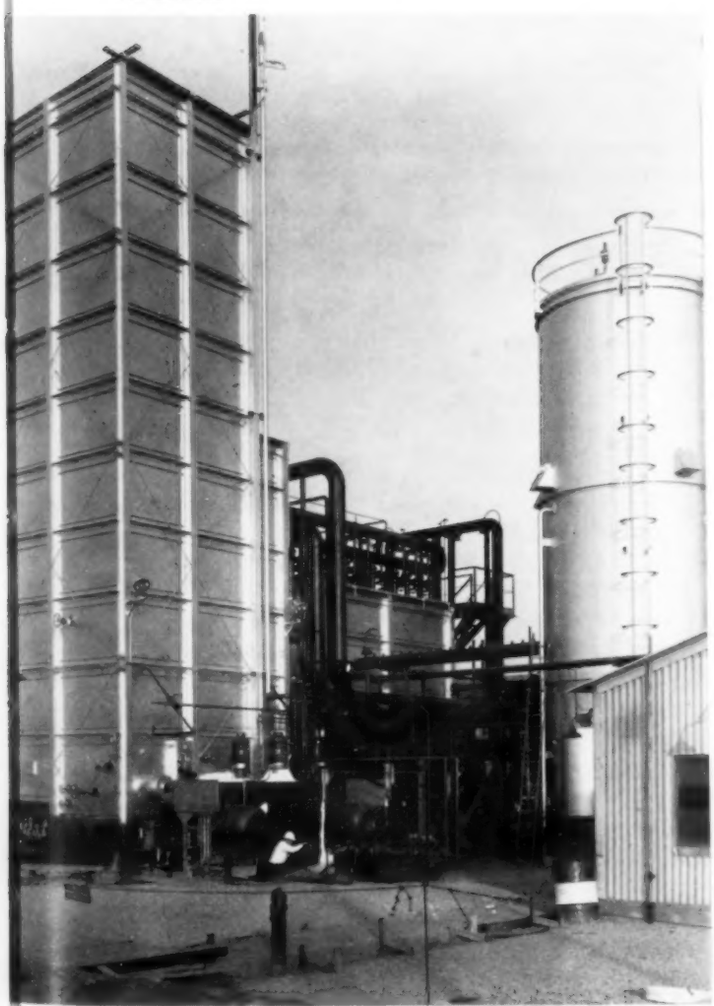
Figure 7 shows an 11,000-hp, steam-driven, air compressor which supplies the air for a 500-ton per day, low purity oxygen generator for blast furnace air enrichment.

The cost of oxygen for the various cases is shown in Figure 8, and is based on capital charges and producing costs at the following rates:

1. Capital charges including 15-year depreciation, interest, insurance, etc., totaling 12 per cent per year of the installed plant cost.
2. Electric power at 8 mills per kwhr.
3. Cooling water at 2¢ per 1000 gal.
4. Maintenance at $1^1/_2$ per cent per year of the installed plant cost.
5. Labor, including one operator per shift at $2.50 per hr and one helper per shift at $2.00 per hr, plus 15 per cent for fringe benefits. One operator per shift has been included with generating stations up to 50 tons per day capacity, and one operator and one helper per shift for generating stations above 50 tons per day capacity.

As an example, the total cost of oxygen from a Case IV 500-ton per day generating station is itemized as follows:

Figure 5—Case III plant has high purity tonnage oxygen generator with distillation column (cold box) located outdoors.



	$ per ton
Capital charges	1.81
Power	3.07
Cooling water	0.12
Maintenance	0.23
Labor	0.27
	$5.50

Case I on the cost curve shows the total cost of oxygen for high purity critical requirements for normal steel mill usage up to about 100 tons per day. The oxygen supply must be maintained on a continuous basis. This is accomplished by multiple generators which produce high purity oxygen under pressure for storage and use. The total cost for all oxygen, including oxygen charged into cylinders, varies from about $26.00 per ton for 7-ton per day capacity down to about $14.50 per ton for 100-ton per day capacity. Expressed another way, this amounts to 10.8¢ per 100 cu ft at 5,000,000-cu ft per month capacity, down to 6.0¢ per 100 cu ft at 72,000,000 cu ft per month capacity.

Case II on the cost curve shows the total cost for the production of high purity oxygen to furnish critical steel mill uses and the large volumes of high purity oxygen for combustion requirements such as the top-blown converter. The oxygen supply must be continuous as in Case I. This continuity is assured with two half sized units and gaseous storage, plus a large volume of liquid storage. The total cost for all oxygen, including oxygen charged into cylinders, varies from about $13.20 per ton for 100-ton per day capacity down to about $9.00 per ton for 400-ton per day capacity.

Case III on the cost curve shows the total cost for the production of high purity oxygen for critical requirements and for semi-critical requirements such as open hearth combustion. A single tonnage generator is provided with a large volume of liquid storage to supply the steel mill needs when the tonnage generator is shut down. The total cost for all oxygen, including oxygen in cylinders, is $11.60 per ton for 100-ton per day capacity down to $8.00 per ton for 400-ton per day capacity.

Case IV on the cost curve shows the total cost for low purity tonnage non-critical requirements where standby oxygen is not required, such as oxygen for air enrichment to blast furnaces. A single tonnage generator is provided, which is also capable of supplying a side stream of high purity oxygen. An additional high purity oxygen source such as a Case I type generator may be provided to supply the balance of the mill requirements. The total cost of oxygen, including a 10 per cent high purity side stream is $7.20 per ton for 200-ton per day capacity down to $5.00 per ton for 800-ton per day capacity.

Based on leasing the generating facility, rather than purchasing as is shown here, the cost of oxygen is slightly higher. Leasing, however, provides the important advantage of permitting the oxygen consumer to acquire the complete facility without any capital investment.

There is a correlation between required continuity of oxygen production and oxygen cost. Those applications requiring the highest degree of continuity are served by generating stations from which the cost of

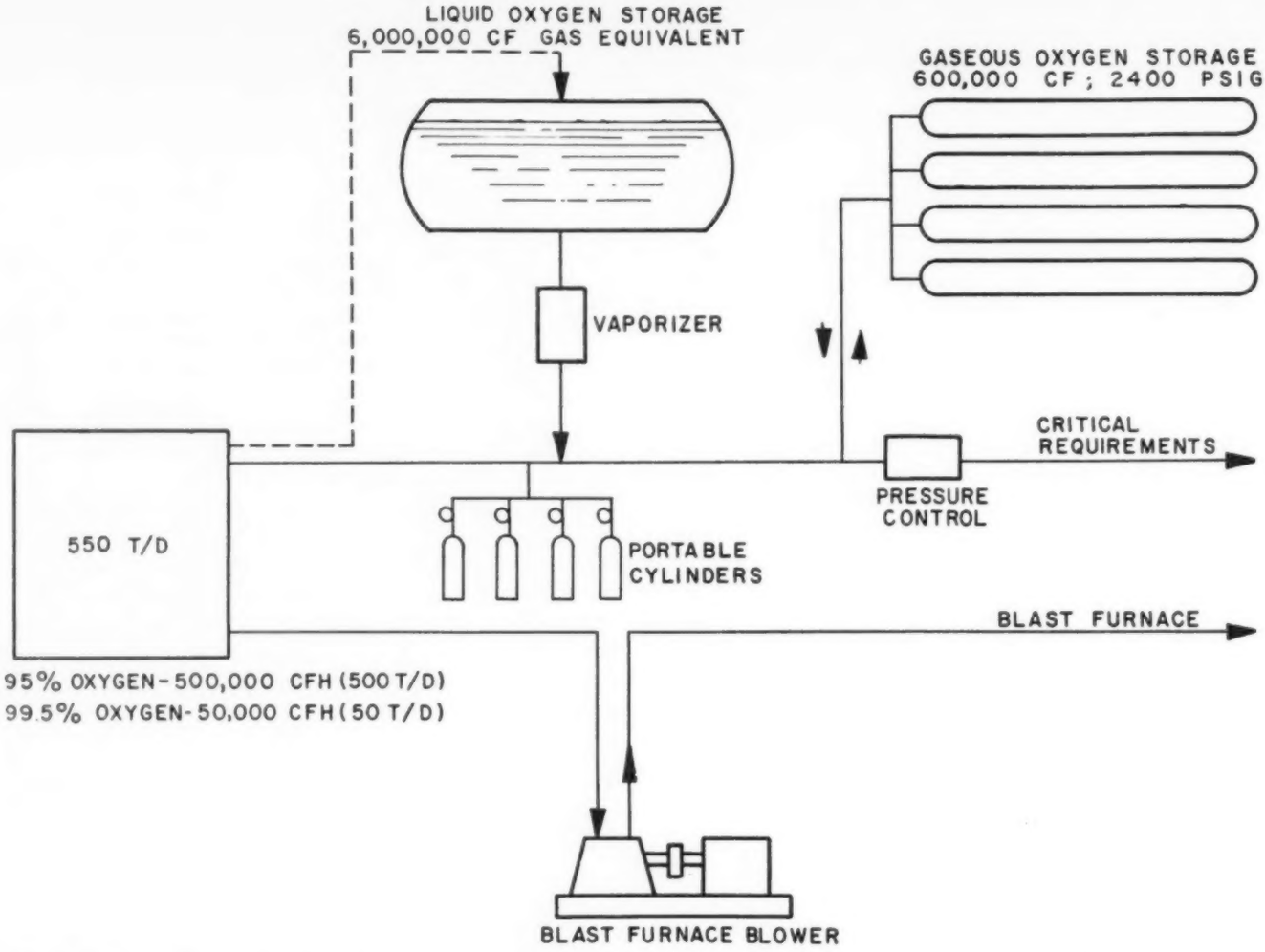
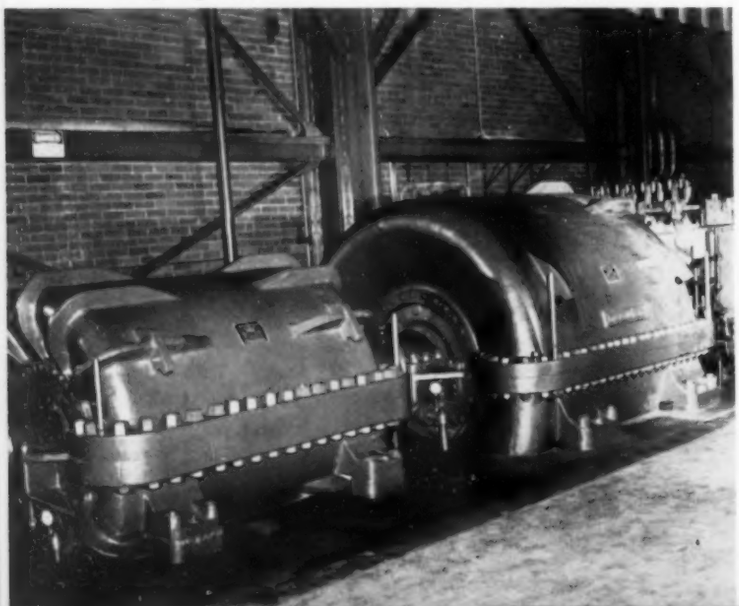


Figure 6—Case IV installation has single low purity tonnage oxygen generator for critical and non-critical oxygen requirement plus a side stream of high purity oxygen and liquid oxygen storage for critical oxygen requirements.

oxygen is higher than those requiring a lesser degree of continuity.

As the interesting science of applying oxygen uses in the steel industry continues to develop, the generating equipment manufacturers will continue to develop stations to meet the new requirements so that this essential element will be available at the minimum cost consistent with the degree of continuity required.

Figure 7—Case IV installation has air compressor (steam drive, 11,000-hp) for a single low purity tonnage oxygen generator for blast furnace air enrichment.



DISCUSSION

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Stephen Vajda: The authors are to be commended on their well written and revealing paper. Their paper points out the various courses available to steelmakers in the third phase of oxygen usage.

In the first phase, oxygen was supplied by specialists in the art as a commodity—much as the dairy supplies milk to the consumer. In the second phase, techno-

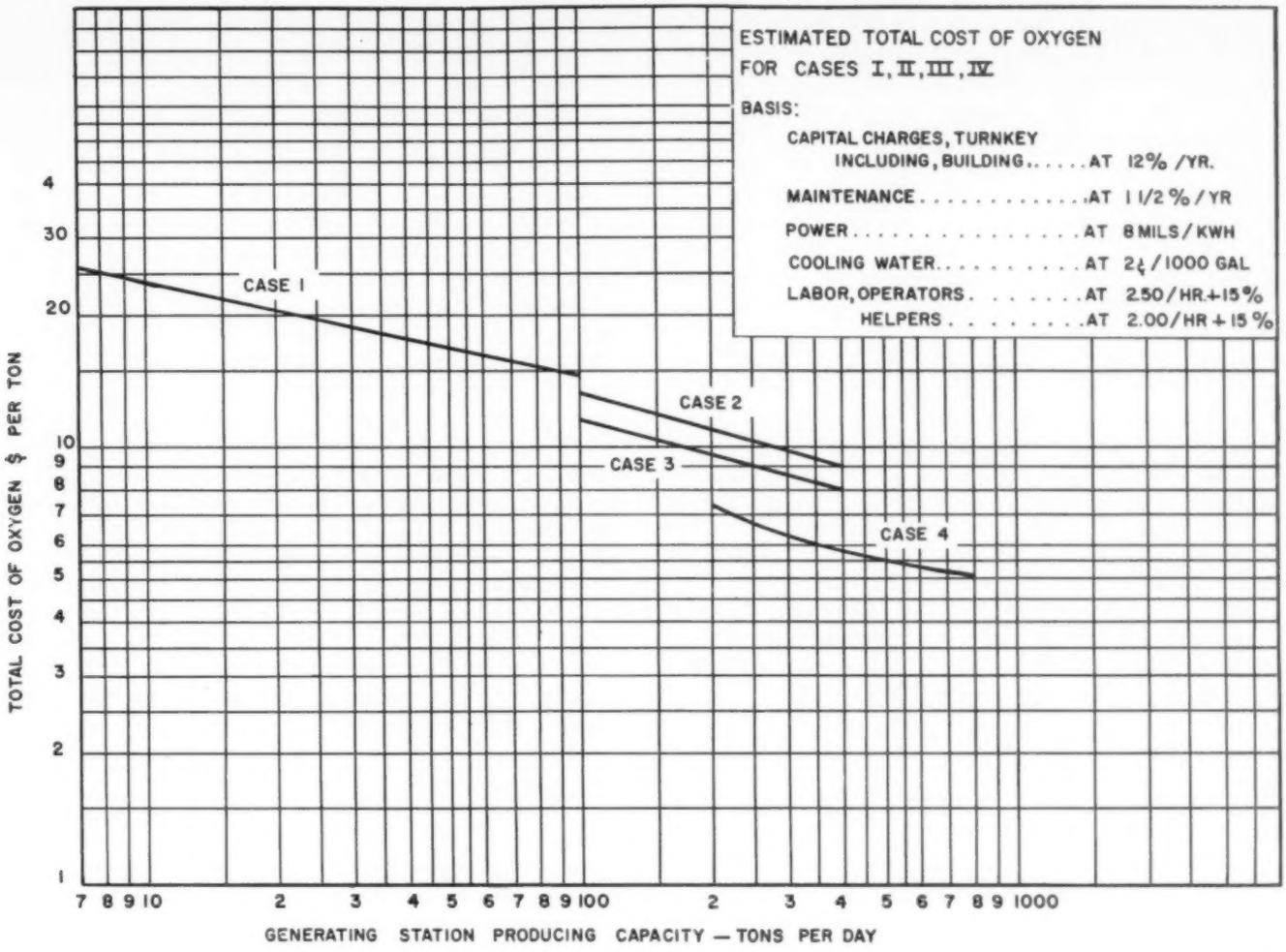


Figure 8—Chart gives total cost of oxygen for Case I, II, III, and IV installations, with equipment furnished and installed by vendor and operated either by the vendor or user.

logical developments and pioneering took the mystery out of oxygen generation and made it a routine process—simpler, in fact, than some of our by-product processes.

We are now entering into the third phase—tailoring the oxygen-generating equipment to meet the demands and special conditions of every plant. It is no longer a question of whether one should buy oxygen from a distributor or whether one should generate it, but rather what kind of a plant will best suit one's needs. The economics of low cost oxygen from generating stations allows for no other choice. There are other questions though that must be answered:

1. Does one buy the plant outright?
2. Should one lease it?
3. Should one sign a long term contract just to buy the oxygen?

In alternate "1" the purchaser normally operates his own plants.

In alternate "2" the purchaser can operate the plant or have the lessor supervise the operation for him.

Alternate "3" differs from the present purchase of oxygen from a distributor in that he builds a special plant just for your needs.

The choice of these alternates will depend on management policy.

At Jones & Laughlin we have all three alternates. This is due to several reasons:

1. The time factor in the evolution of this third phase.
2. Special requirements in each case.
3. Management policy to maintain competition.

At our Pittsburgh works we have four 25-ton, 99.5 per cent purity plants with gaseous storage at 2500 psi. This installation is similar to Case I presented in the paper. This was our first installation. At that time the 25-ton unit was the largest standard unit available. We wanted more than one unit, to permit flexibility in handling changes in steel production rates, and, also, to reduce curtailment due to deriming. We are leasing the units, but installed them ourselves. The oxygen is used for scarfing, carbon reduction, bottling, etc.

At our Aliquippa works we have two 115-ton, 99.5 per cent purity plants with gaseous storage at 450 psi; also, have liquid storage for deriming periods. This installation is similar to Case II. These units are also leased, but they are being installed by the lessor and will be run under his supervisor. We chose two units instead of one to give us availability of oxygen at all times. About 22 per cent of the oxygen will be for steel mill use—the remainder is for the oxygen converter process.

At our Cleveland works we will have oxygen supplied to us from a plant rated at approximately 67 ton, 99.5 per cent purity with gaseous storage. The distributor will build and erect his own plant and sell us oxygen at a scheduled rate. The production of this plant is to be implemented by driox oxygen during

shutdowns. All of the oxygen is for steel mill use.

C. E. Duffy: The oxygen generating facilities at the Sparrows Point plant are of the type shown in Figure 1, Case I of the paper presented. Four units each rated at 7000 cfhr of 99.5 per cent oxygen purity are installed at present. Plant usage is such that 600,000 cu ft of gaseous storage capacity is required. A pipeline system supplies hand and machine scarfing, cutting, steel fabrication and miscellaneous small consuming applications. Approximately 150 portable oxygen cylinders per day are filled for use in locations not serviced by the pipeline system.

In addition to the oxygen, each unit produces 22,000 cfhr of 99.5 per cent pure nitrogen for use in our HN annealing gas station. Dissociated ammonia is added to the nitrogen stream and the mixture then passes through a clean-up train which consists of a catalyst for oxygen clean-up and a refrigerated cooler followed by a desiccant type drier for dew point control. The HN gas mixture with a 4 per cent hydrogen content is used for batch annealing.

The utilization of both the nitrogen and oxygen streams from the units influenced both the location of the station in the plant and size of units installed. To maintain consistent purities of both the nitrogen and oxygen streams requires efficient operations and operation of the units at about 3 per cent below rated capacity. The availability of these units is important, since the nitrogen stream involves batch annealing. These units are available 95.5 per cent of the time which we consider very good.

D. M. Seeley: The authors have very capably described some of the generator design that has evolved with increasing utility and application of oxygen to steelmaking. Those responsible for attainment of optimum benefits from this new tool will recognize the conditions illustrated and concur in the approaches to their solutions described by the authors.

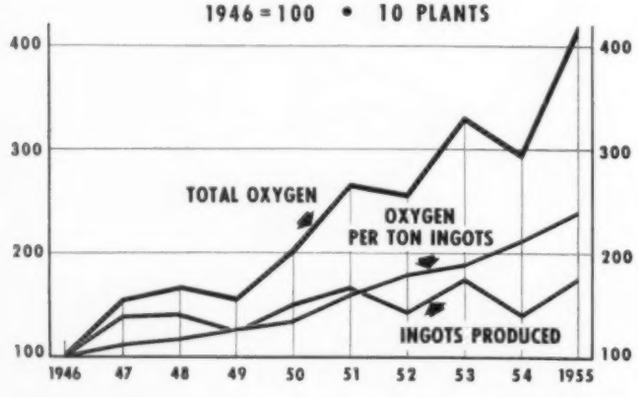


Figure 9—Oxygen usage has risen at a greater rate than the production of steel ingots.

Other provisions for assurance of continuity of oxygen supply are known as follows:

1. It may be advisable to protect continuity of generation against power failure by providing different drive systems on multiple units. These may be combinations of steam, electric (own and purchased), diesel, and other.

2. With the steelmaking future appearing to require expansion in oxygen supply, the design of generating systems must further be integrated to meet continuity, storage, and ultimate expansion requirements.

The increasing utility and application of oxygen to steelmaking is illustrated by experience in 10 plants of U. S. Steel. Over the 10-year period 1946 through 1955, as shown in figure 9, while production in ingots at these plants has increased approximately 75 per cent the utilization of oxygen per ton has increased about 140 per cent, cumulatively effecting an increase in total oxygen utilization of 317 per cent.

Future plans for oxygen at these plants, in terms of generating capacity contracted, represent utilization of about 850 per cent over the 1946 amount.

J. H. Zimmerman: Keeping oxygen supply equal to mill demand is a problem which concerns all of us, and I would like to congratulate the author for focusing on some of the facets of the problems that face both the regular oxygen supplier and the private oxygen plant promoter. Many of these problems are the same for both. We have different approaches to their solution.

We have studied this paper, as we were asked to do, and have found nothing in it with which we disagree in any substantial manner. Some of the data presented are not in keeping with our own experience, although this is a question of degree. In the case of other data, we feel that they cover rather idealized conditions rather than practical ones.

Obviously, the most economical method for supplying oxygen to any particular mill depends upon the actual demands of that mill. Based upon the conditions given in the examples in the paper, we feel that the consumption curves shown in Figures 1 and 3 are not typical of our experience. For example, Figure 1 shows the load curve over 20 hours for a mill using high purity oxygen for scarfing, maintenance and decarburization. There are several mills in this country that have single scarfing machines with demand rates as high as 500,000 cfhr. At even a 20 per cent duty factor this means a load of 100,000 cfhr. Other mills have machines with lower demand rates, but higher duty factors. Others have multiple scarfing machines.

Scarfing machines produce demands on oxygen supply that are much more fluctuating than hand-scarfing. Anticipation of this fact is what led to the effort we devoted to the development of the liquid oxygen supply system in the early 1930's, parallel to the development of the scarfing machine itself. And then there are other sizable demands for oxygen that produce load fluctuations besides scarfing, maintenance and decarburization, such as heavy scrap preparation, plate slab trimming, merchant mill uses, etc.

The fluctuation shown in Figure 1 which is roughly 50,000 cfhr (from a low of about 10,000 cfhr to a high of about 60,000 at about 6 pm) would not be typical of the load variations we have encountered.

At first we found some confusion between the description of Case 2 and the illustrations of the load curve in Figure 3, but it was apparent on looking at the figure that the consumption was based on the 2-converter installation. This was confirmed by a study of the proposed supply installation—both because of the rated production and because the backup of oxygen supply comes as a surplus from the main production stream. Probably because of the experience our company has had with supplying extra oxygen in a hurry, we

feel that an internally-supplied reserve system is only a partial answer. The purpose of this storage is to cover periods when the plant is shut down for maintenance or thaw. I believe Mr. Cummings will agree that the period in plant operation that is most vulnerable is during the first week or so when a plant is put back on stream after shutdown. This, of course, is the same period in which the reserve storage is at its lowest ebb.

Because certain other data in Case 2 are not given, such as the excess of installed capacity over available consumption and the per cent of over-capacity that is bled off as liquid for reserve storage, we cannot comment further on this example.

Getting back to the general subject of demand curves, it has been our experience that the majority of steel producers, even with the help of the oxygen people, tend to underestimate oxygen needs and are not fully aware of the fluctuating characteristic of mill demands.

We have also studied Mr. Cummings cost figures. We do not have any basic argument with them because they agree so closely with ours. We recognize, however, that these are ideal conditions and not a specific quotation. The indicated cost of capital investment seems to us to be most conservative, providing interest on investment about equal to that of a government bond. This phase of the oxygen business is of considerable interest to us as our plan for on-site plants includes investment of the plant cost, supervision of plant operation, and sale of the oxygen.

Concerning the figures on power, we feel that 8 mills is a good average figure nationwide, but we feel that the charge of $3.07 a ton for a 500-ton-a-day plant is on the low side. The amount of power (384 kwhr) is fairly adequate for a 500-ton-a-day low-purity low-pressure plant in steady operation. It does not allow very much power for compression of oxygen in cylinders and makes no provision for side stream of liquid oxygen for backup.

With respect to maintenance cost, we agree that 1½ per cent of capital investment for both maintenance materials and labor may apply for short periods but is too low as an average for the 15-year period of the amortization.

We agree with the labor charges, when they are presented as an example of how low costs can be calculated. Depending upon accounting methods, there may be an overhead charge on the direct labor or in its place a charge for supervision,—or both. In any event, in a practical condition the charges would have to be higher.

The cost figures that have been given in the paper we feel can be justified in each instance provided it is clear just what they cover. They are not figures that would be used in bids or quotations.

The most important point that may have been made through this presentation and discussion is that in our U. S. economy, there is plenty of room, in spite of competing factors, for a specializer, whether as the buyer of oxygen for a steel mill, a proponent of do-it-yourself in oxygen production, or an oxygen supplier, as long as he understands the economic and competitive forces that are continually moving us to better results.

Donald E. Cummings: It is certainly a pleasant surprise to see that Mr. Zimmerman is in general agreement with the facts as presented. I am sure that Mr. Zimmerman realizes that the consumption curves used in Figures 1 and 3 were typical ones used for illustration purposes only and were not meant to denote an actual consumption pattern as his detailed comments indicate. The broken consumption line occurring about 10 a.m. in Figure 1 indicates an extremely large off-scale peak usage of very short duration such as a scarfer load. Before an installation size is decided upon, an intensive study is made of the steel plant oxygen requirements, present and future, so that the proper size generating units and storage are selected.

I agree with Mr. Zimmerman's comment to the effect that the majority of steel producers tend to underestimate their oxygen needs; in fact, at almost every one of our 30 or so lease installations, we have added additional capacity after the original installation.

The producing costs, capital costs, and total cost of oxygen referred to in my paper are based on our experience and the experience of our lease customers in the steel industry.

I heartily agree with Mr. Zimmerman's concluding remarks to the effect that the ultimate winner is the customer, in this case the steel industry, when competitive forces are active in the American economy.

H. I. Riegel: The paper presented by Mr. Cummings is very timely in view of the recent developments within the steel industry. The use of oxygen in the steel industry has been increasing at a very moderate rate. This rate probably would have been greater had the cost of oxygen been lower. Recent developments in the oxygen industry have caused the cost of large volume oxygen to the steel industry to lower to a point where economic considerations encourages development of new processes and uses. It appears quite evident at this time that the use of oxygen in the steel industry will increase in the future at a much greater rate.

The author in reference to Figure 1 states that: "This system is very flexible in that one or more generators may be easily shut down or started, depending on the volume of oxygen in the storage tank and rate of consumption." The general impression is that all that is necessary is to push a button for either operation. I would like to ask the authors what the time element is between the pushing of the button and the production of quality oxygen?

Could the authors tell us how long it takes to train plant personnel to become proficient operators?

The present system of making oxygen is a heavy user of power. Has there been any recent development work which would indicate lower power use and, of course, lower priced oxygen in the future?

I congratulate the authors of the paper for their interesting presentation of a timely subject.

Donald E. Cummings: Mr. Riegel's initial comments are certainly very pertinent. It almost always follows in the American economy that, as the cost of a product is brought down through any means, such as competition or increased productivity, the demand for the product goes up. Some recent surveys show that oxygen was used at the rate of 30 cu ft per ton of steel produced in 1940, 40 cu ft per ton in 1945 and 50 cu ft

per ton in 1950. Then in 1955 and 1956 as on-location generators and other factors brought the cost of oxygen down, the usage went up sharply to about 250 cu ft per ton. Our market research group predicts a usage rate of 600 to 800 cu ft per ton in 1960, as more oxygen is used in blast furnaces and open hearths, and more top blown converters are placed in operation.

Mr. Riegel's question on ease of start-up and shut-down is a good one. Of course, shutting down is no problem, just press the stop button on the main air compressor supplying the air for liquefaction and distillation. When starting up a unit, the length of time to regain production is variable. On the smaller packaged units from 7 to 25 ton per day capacity as in Case I, they can be off-stream for 12 to 18 hours and be placed back in production in about three to four hours, since some liquid oxygen remains in the distillation column. After a shut-down of one week or longer, the start-up from warm conditions takes about six to eight hours. On the larger tonnage units, start-up periods range from about six to eight hours after a short shut-down up to about 18 to 24 hours from a warm start.

Regarding training operators, our preference is that the operators be supplied by the customer so that he has complete control over the operation and is entirely free from outside source interruptions such as strikes, transportation delays, etc. This is the case at J & L, Weirton, Great Lakes, Bethlehem Steel and other stations where the customer selected men from his operations to be trained as operators and had these men present at the site during the equipment installation period for indoctrination. These men also visited our manufacturing facilities for training. Our operator-training group then assisted the customer's operators for about three to six months after start-up, again depending upon the size and complexity of the units.

In general, good air compressor operators can be made into good oxygen plant operators in about six months, as they bring with them to the new job about 50 per cent of what they need to know in the operation of an oxygen plant.

On the question regarding reduced power requirements in the future, our and other companies' research and development personnel are constantly working on this matter. Our feeling now is that we are approaching the minimum conditions regarding the amount of power required to liquefy and distill air into its components. Of course, the conditions at which the oxygen is required to a large extent determine the amount of power required. For example, our 500 ton per day unit at Weirton makes 95 per cent pure gaseous oxygen at atmospheric pressure for about 1.80 kwhr per 100 cu ft, but our liquid producing units installed here in California for the guided missile program require about 3.5 to 4.0 kwhr per 100 cu ft because of the refrigeration that is sacrificed when the oxygen product is withdrawn in liquid form.

AISE ANNUAL CONVENTION

GOLDEN 50 YEARS ANNIVERSARY

September, 23, 24, 25, 26, 1957

Penn-Sheraton Hotel

Pittsburgh, Pa.

Continuous Normalizing and Heat Treating Equipment for Steel Plate

By HORACE DREVER
President
and
N. K. WILLIS
Chief Engineer
Drever Co.
Bethayres, Pa.

. . . . heat treating of structural steel and particularly plate may become an important element in steelmaking operations . . . . better design properties will lead to wider usage of such material . . . .

▲THE production of steel plate represents a sizable fraction of the total steel output of the country, last year amounting to over 6,500,000 tons. Very little of this plate production has been shipped from the mill in the heat-treated condition, however, plate of this quality is receiving increasing attention and production is rising. In the construction of pressure vessels, earth moving machinery, mining machinery, buildings and bridges, a large number of uses are being found. As the advantages of high strength material combined with light weight is brought to the attention of designers, the use of such material is bound to grow.

A little more than a year ago, the first large fully automatic continuous high output plate heat treating line was placed in production. The line was designed primarily for the production of armor and commercial heat-treated plate. However, we were to keep in mind that it would be used for normalizing carbon plate as well. The line includes a charging transfer car, next a 145-ft hardening furnace, a pressure quench, a quench transfer car, a 200-ft tempering furnace, two conveyor tables and at the end of the line two transfer cars. The control room was originally alongside the quench but was moved later on to its present position over the quench transfer area. A later addition to the line are the plate layout and test block cutting tables. They are located beyond the building columns and to the left of the quench transfer tracks.

The equipment installed beyond the building columns and paralleling the tempering furnace is not necessary to the heat-treating line. It was installed primarily to serve a 200-in. plate roller leveler, not part of our contract, but necessary to the complete production facilities of the plant. The authors are pleased to add, however, that in the past year of operation the leveler

Figure 1 — A number of control innovations feature a new plate heat treating line at Lukens Steel Co.

has been used very little to flatten plate processed in the heat treating equipment here described. The conveyor table and, at times, the car are under the control of the furnace operator and thus can be used as alternate equipment and especially as cooling tables when both furnaces are used for normalizing plate.

The line is completely of the roller hearth type, all rolls driven, providing automatic handling of the work. All drives are reversible and operated from the central control pulpit. Electric clutches provide the proper drive arrangements as required.

Within the maximum temperature limits of the furnaces, the line is capable of handling plate up to 172 in. wide, $\frac{3}{16}$ in. to 3 in. thick and 480 in. long if quenched, and 575 in. long if normalized and air-cooled. Based on armor or other similar heat treated plate, 102 in. wide, 1 in. thick, 380 in. long with 92 per cent effective hearth loading, approximately 3 ft between plates; a hardening cycle of $2\frac{1}{2}$ hr; a tempering cycle of $3\frac{1}{2}$ hr; the rated capacity of the line is $10\frac{1}{2}$ tons per hour. The maximum capacity is 22 tons per hr of hardened and tempered plate based on the maximum width, thickness and length with a 92 per cent end to end hearth loading.

Figure 2 — Burners give long luminous flame and are of the combination oil/gas type.

TRANSFER CARS

The transfer cars are all similar in design regardless of their place and function in the overall line. The charging car (Figure 1) shown with plate ready for charging to the hardening furnace is representative of all cars. The car is essentially a roller table, 190-in. wide x 52-ft end to end rolls. All rolls are of tubular steel mounted in self-alining roller bearing pillow block bearings. Each roll is driven by a roller chain sprocket and continuous chain through a reduction unit, magnetic clutch, brake and a-c motor at a fixed speed of 100 lineal fpm. The car is supported on four two-wheel trucks on rails at floor level, and a separate a-c motorized drive, driving four of the eight wheels, gives a maximum car speed of 50 fpm. Power to the car is supplied through cable reels mounted on a car and through cables in a trench in the floor.

Photo-electric cells are utilized to limit plate travel on the rolls, to position the cars in line with various other equipment, and to prevent plate movement beyond the end of the car unless the car is in a position to receive or discharge plate onto or from other parts of the line.

Permission switches or remote control of the cars was installed at floor level by which control is taken away from the operator as necessary in case of emergency or maintenance.

The charging car is a transfer car which can move out into the main building and plate handling area to be loaded by overhead crane. Keeping the plate storage and furnace area separate has proven to be an asset to the facilities.

HARDENING FURNACE

The hardening furnace (Figure 1) designed for a maximum operating temperature of 1650 F and minimum of 750 F, has a wall to wall dimension of 190 in. and is 145 ft long. It is fed continuously at furnace speed from the charge car through swing gears engaging the car roll drive to the furnace drive.

The main furnace drive is an electronic a-c d-c drive unit of 4 to 1 variation that through a mechanical speed changer will give 8 to 1 overall, or a roll speed of 0.6 to 4.8 fpm or time in the furnace from 30 minutes to four hours. The roll drive is sectionalized, although a continuous type chain drive, and is powered by a line shaft paralleling the furnace with take-offs at the sections through a reducer and shear key roller chain sprockets. Automatic chain take-ups were designed to take care of chain slack when the roll drive is to be reversed.

The run out section at the discharge end of the furnace is designed for both 30- and 45-ft long plates, and through clutches selected in the pulpit the proper setup is arranged to discharge plates one at a time at 175 fpm to the quench or on through for air cooling as required. Single chains suspended from the furnace roof indicate to the operator by light and audible signal when the work has advanced on to the runout section and is ready for discharge.

The steel casing was designed to expand longitudinally within itself, both ends being fixed and the concrete foundations were also designed to move, if necessary, in the same direction as the casing. No transverse expansion was provided for except in the arch supporting steel.

The rolls in the furnace, designed for a uniform live load of 3500 lb per roll, are of 14-in. diam chrome-nickel alloy and we believe the largest and longest centrifugally cast barrels used in a furnace up to that time. Design was based on a unit stress of about 1800 psi or roughly 75 per cent of the limiting creep stress of 1 per cent in 10,000 hours of the particular alloy. To protect the considerable monetary investment in these rolls, we used over-temperature protection thermocouples under one roll per temperature control

zone, and an electric alarm system on each section of roll drive that will warn the operator of roll rotation failure whatever the cause.

The size and weight of the furnace rolls made it necessary that replacement should not be a serious maintenance problem and therefore the furnace was designed with removable castable refractory bungs under each roll so that the roll could be lowered to the furnace floor and removed. To the credit of all those involved in the roll design, it has not been necessary up to this writing to remove any rolls from the furnaces.

The refractory lining is of insulating firebrick and block and one course of hard brick on the furnace floor to withstand the mechanical abuse of roll installation and removal. The furnace has a flat suspended arch of rammed plastic, 9 in. thick with fire brick anchors on 12-in. centers throughout, together with 2½ in. of light weight castable block insulation on top to seal the entire roof construction. The air setting plastic was used to give initial strength to the arch during the anticipated delay between ramming of the arch and firing of the furnace when a positive ceramic bond of the arch would be assured. The steel frame doors are lined with light weight castable with cast iron sections on the exposed surfaces.

The burners chosen for the furnace (Figure 2) were the long, luminous flame, tempered flame combination oil/gas type. As shown in the illustration, with burners at somewhat less than full firing, the hearth coverage could not be much improved upon. The furnace is divided into seven temperature control zones each about 20 ft in length. The first three zones or heating zones are over and under-fired and the last four zones or holding zones, over-fired only. Burner spacing in the holding section of the furnace is 4 ft staggered, or 8 ft on each side, and is a spacing only possible in a continuous type furnace.

The total maximum fuel input to the furnace is 56,000,000 Btu's per hr or about 35,000 Btu's per hr per sq ft of hearth area in the heating section, and about 15,000 Btu's per hr per sq ft in the holding or soaking end. The average fuel consumption at the maximum capacity of 22 tons per hr is estimated to be about 25,000,000 Btu's per hr with the excess burner capacity required to get sufficient air on the furnace to assure temperature uniformity.

All zones of the furnace have separate combustion air blowers and safety control valves with separate gas pilot systems. No flame failure protection is provided other than the gas pilots, safety shut-off valves for gas and oil, and low fire oil shutoff valves.

The burners in each zone operating 10 to 15 per cent excess air are controlled by adjustable port air, gas and oil valves all operated in tandem by a pneumatic valve operator with positioner in turn controlled by pneumatic recording controllers equipped with integral by-pass for manual control. Over-temperature protection controllers indicating the zone temperature on the rolls actuates a 2-way, 3-port solenoid valve in the air control line to the valve positioner bleeding off air and driving the valves to low position should the temperature exceed the set point.

To help maintain temperature uniformity in the soaking zones of the furnace where we over-fired the hearth, we intentionally flued the furnace at the discharge end through the walls above hearth level. This forced the products of combustion from the heating end to travel toward the flues and help to maintain the furnace temperature under the plate.

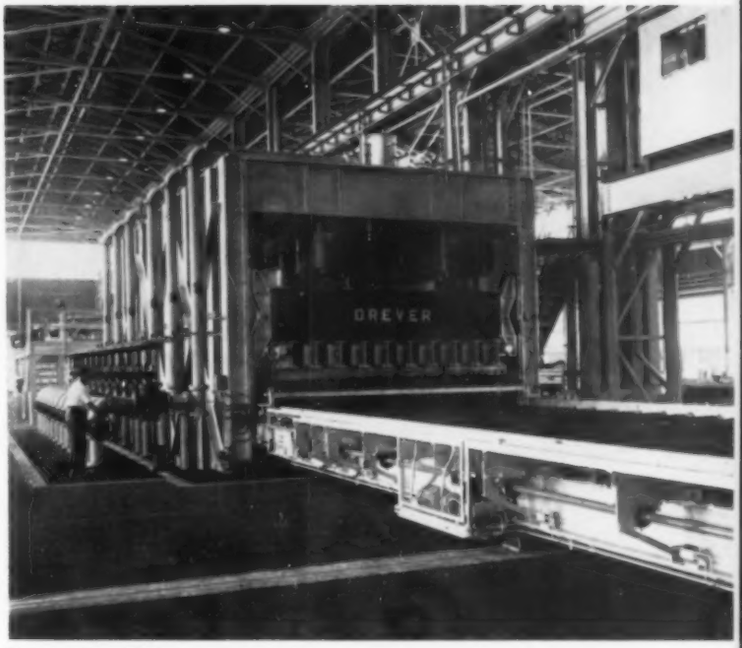


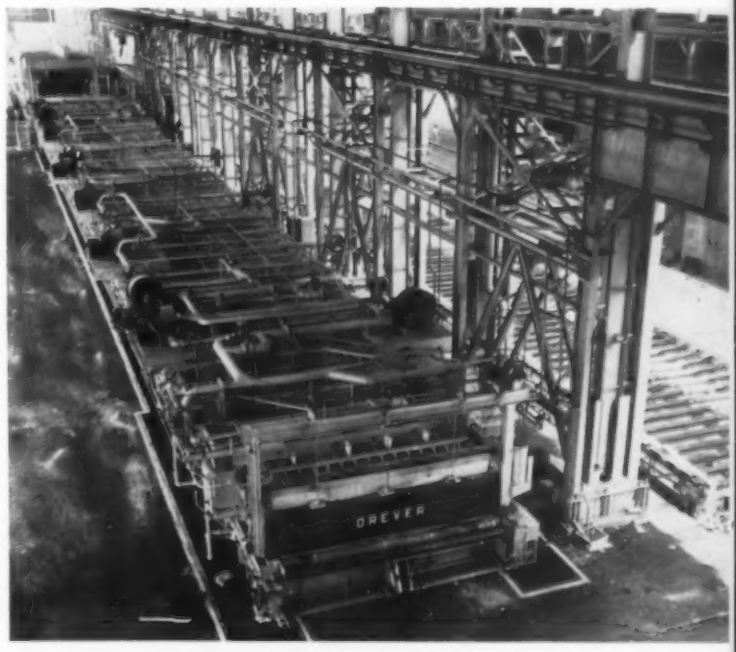
Figure 3 — Pressure quench can exert a maximum pressure of 2500 tons.

PRESSURE QUENCH

The pressure quench (Figure 3) has an effective width of 180 in., a length of 45 ft and clear height of 18 in. It is oil hydraulic operated to exert a maximum pressure of 2500 tons on a 172-in. wide x 40-ft long plate during water spray quenching.

The press is not a forming or flattening press and is intended only to keep the plate flat during the

Figure 4 — The tempering furnace is a high temperature unit.



quenching cycle. It is structurally designed for deflection rather than stress, and designed for a maximum pressure of 4.5 tons per sq ft of plate being quenched. Work is conveyed into the press at the furnace runout speed on tubular steel rolls all driven by a continuous chain-drive connected through clutches to the furnace runout drive. The rolls are mounted on a structural table, mounted and guided in the press structure, and raised or lowered by hydraulic cylinders. A stationary platen between and below the rolls and movable platen above, guided on the press columns and actuated from above by 26 hydraulic cylinders, 12 for movement with all 26 exerting the maximum pressure, maintains the plate flat during quenching.

A self-contained, oil hydraulic unit complete with solenoid control valves, boosters, pumps and reservoir is used to supply the required control of the ram and carriage table and maximum oil pressure of 2500 psi. A pre-fill system is utilized to fill the 26 cylinders rapidly on closing the press, assuring full volume in the cylinders before admitting high pressure from the booster circuits. By means of electrically selected circuits, high pressure can be applied to one, two, or three sections of the press depending on plate length and thereby preventing damage to the structure not containing plate. Pressure control to the inlet of the hydraulic boosters is controlled by the operator.

Eight hydraulic equalizing cylinders, two at each corner of the movable ram, are interconnected in closed piping circuits that prevents unequal movement of the ram during its vertical travel. Should unequal movement still occur, pressure switches in the circuits automatically returns the press to the open position and it cannot be closed until the reason for such unequal movement is corrected.

Quench water, supplied by three 8000-gpm pumps at 140-ft head, is fed to the spray pipes located among the platens both above and below the work in six sections. Each section is controlled by an air solenoid valve controlling air to a diaphragm-operated water control valve shown on the left of the illustration. Air pressure regulated by the operator controls the opening of the diaphragm valve and thus the amount of water to the sprays.

CONVEYOR TABLES

The conveyor or cooling table, 190 in. wide x 206 ft long, consists of a rigid steel structure supporting tubular steel rolls mounted in self-alining anti-friction roller bearings. All rolls are driven by sprocket and continuous roller chain in four sections of about 50 ft each. The main drive is a 3 to 1 variation electronic a-c d-c unit powering a line shaft paralleling the table. Take-offs from the line shaft through a reduction unit and shear key sprocket powers each section of the drive. One end section is isolated from the main drive through clutches, so that, if a plate must wait for a transfer car to receive it for transfer to the tempering furnace, the remaining 150 ft of table may still be used. The drives are reversing with lineal roll speeds of 50 to 150 fpm. Photo-electric cells are again used here to prevent running plate off the end unless a car is in position to receive the plate.

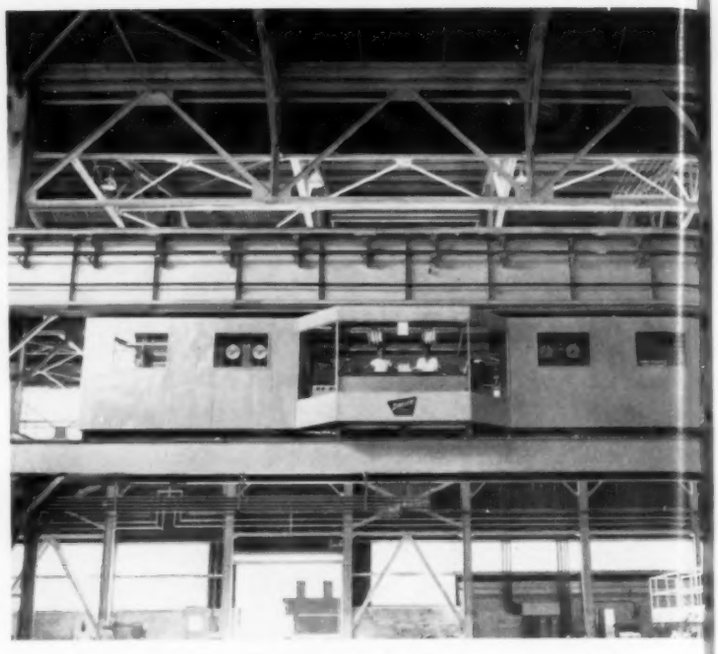


Figure 5 — Control room is located high in the building.

The alternate conveyor table normally serving the 200-in. plate leveler is identical except it is 28 in. wider in order to convey 200 in. wide plate and has no isolated drive section.

TEMPERING FURNACE

The tempering furnace (Figure 4) so called as that is its normal function in the heat treatment cycle is 190 in. wall to wall inside and 200 ft long. In order to provide additional normalizing facilities, it was made a high temperature furnace also. In all respects it is the same as the hardening furnace except for length combustion, and temperature control zones.

The furnace is reversible both in heating and drive. Although normal work flow is toward the quench, it is possible to reverse its direction and that is particularly useful when normalizing plate in both furnaces, thus helping to relieve congestion at the quench car area. Consequently this furnace has a double runout of 30 or 45 ft at each end and is controlled from the operating room in the same way as the hardening furnace.

The furnace has an 8 to 1 over-all drive variation like the hardening furnace, giving plate speeds of 0.6 to 4.8 fpm or time in the furnace from 45 minutes up to six hours. Plate is fed continuously at furnace speed from the car, but again discharged rapidly one at a time.

Combustion is divided into nine control zones varying in length from 16 to 32 ft. The two zones at either end are over and under-fired, but only firing under the hearth in the heating end as determined by the flow of work. The remaining five zones are over-fired with burner spacing spread out to eight feet per side or four feet stagger. The burners are of the long, luminous flame, tempered flame combination oil/gas type as used in the hardening furnace. Maximum fuel input is 66,000,000 Btu's per hr or about 32,000 Btu's per hr per sq ft of hearth area in the heating sections and 15,000 Btu's per hr per sq ft in the soaking section.

Approximate fuel consumption at maximum capacity of 22 tons per hr is 30,000,000 Btu per hr with the maximum burner capacity again necessary to get sufficient air on the furnace for temperature uniformity.

Zone control is likewise the same as the hardening furnace with adjustable port air, gas and oil valves all operated in tandem by pneumatic valve operator with positioner. Burners operate with 15 to 20 per cent excess air and maintain excellent temperature uniformity at the tempering range of 1250 F. Anticipating the possibility for the need of constant air on the burners to give us this uniformity at 1250 F in a furnace so wide, we provided a manual valve in by-pass lines around the adjustable port air valves. They, however, have not been used to date. Should some lower operating temperature ever be desired the by-pass feature may be put to some use.

No flame failure protection is provided other than gas pilots, safety shut-off valves for gas and oil, and shut-off oil valves for low fire on each zone.

Controllers are pneumatic recording type with integral by-pass for manual control. Over-temperature indicating controllers are used with thermocouple on one roll per zone to protect the rolls from excessive temperature and/or control couple failure.

The furnace is vented through flues at each end located in the side walls above hearth level. Flue dampers are provided so flues in the heating end can be closed, thus forcing the products of combustion towards the discharge end helping to maintain temperature uniformity throughout.

LAYOUT AND CUTTING TABLES

The layout and test block cutting tables are similar in construction to all conveyor tables with the addition of side positioning devices to straighten plate on the table. The first table called the layout table positions the finally heat treated plate under a travograph mechanism that scribes the plate for final gas cutting. Test blocks are also layed out at this time. The plate is then conveyed to the cutting table where it is again positioned under a travograph and the test blocks previously layed out are cut and sent to the laboratory for analysis. All controls for these two tables are mounted on the travograph cars that move back and forth on rails parallel to the tables. The travograph equipment and cars were supplied by others.

Figure 6 — A television system enables the operator to see what is going on in all parts of the line.

CONTROL ROOM

The nerve center of the entire installation is the control room (Figure 5) located high in the building and at that point in the line where the greatest activity takes place, or what might be called "plate-traffic" is the heaviest. Here the operator has visual observation of the work and can see directly all movements that he has at his command.

Centered in the room are the control desks, telephone, two television receivers, and air conditioning unit. The left wing towards the hardening furnace contains the zone temperature controllers for that furnace, the toilet facilities and drinking fountain. In the right wing are the zone temperature controllers for the tempering furnace and relay panel containing all the relays that set up and maintain the proper operating sequences.

GENERAL

On the mill floor located close by the control room is a 54-compartment motor control center containing the starters for all a-c motors, circuit breakers, and transformers for control power.

A six-telephone circuit is installed with one phone set in the control room and the other five located about the line. Conversations can be held between any two phones or up to all six should the situation demand it.

To peer into the far reaches of the plate heating line that are out of sight of the operator, a closed circuit television system was installed (Figure 6). The system includes the two previously mentioned receivers mounted in the control room which are studio type, 12-in. monitors. Six "TV" eye cameras modified for video operation are located strategically about the line. Behind or adjacent to the cameras are banks of flood lights each totalling 9000 watts to illuminate the area. Each camera has a control unit and three of these units are switched into one line amplifier and then into the monitor. Switching is also arranged so that, should an emergency occur, any camera scene can be viewed on either monitor.

Centralized lubrication consisting of several hand operated pumps and metering valves is provided on all equipment except for three of the transfer cars and was omitted there only for reasons of economy. These cars, at the two extremities of the line, are stationary a good part of the time as plate is entering the furnace and as lubrication was not frequently required it did not, at that time, justify a centralized system. However, all points of lubrication on these three cars were tubed to central and accessible locations.

After the preliminary design and line layout was

definitely established, the project required some 27,000 man-hours of design and drafting, and approximately 70,000 man-hours of erection involving five building trades. The above does not include the man-hours expended for either foundation design or its installation.

So, from high up in the control room some 18 ft above the floor, surrounded by 75 odd switches and push buttons, 50 odd multi-colored indicating lights, and 25 other miscellaneous but necessary pieces of equipment, one operator moves steel plates weighing up to 42 tons each throughout the 600-ft length and 100-ft width of the production line. Through his eyes, the eyes of "TV" and with 137 relays interlocking his equipment, thus preventing possibly 90 per cent of the human error, he controls equipment that produces flat heat treated plate faster and cheaper and with more efficient quality control than is possible by other methods. Given a good product mix of like material and gages, he can process material as fast as 36 batch or car furnaces and without all the plate handling involved.

The authors would be the first to admit that there is room for needed improvement in this first high output production line. Changes were made during our design and engineering and minor ones, even as late as the erection of the equipment, have been made during the first year of operation; and will be made in the near future. A second production line, slightly smaller in size but not in maximum capacity, was placed into operation late in 1956 or early in 1957 having still further improvements and additional features.

We endeavored to design and build for the furnace industry equipment of high output capacity to produce quality, fully heat treated or normalized, carbon or alloy steel plate to meet the growing demand from the rolling mill. We believe we have succeeded.

DISCUSSION

PRESENTED BY

D. M. SEELEY, Project Development Engineer, United States Steel Corp., Pittsburgh, Pa.

N. K. WILLIS, Chief Engineer, Drever Co., Bethayres, Pa.

ROLLAND L. HOFFMAN, District Manager, Bloom Engineering Co., Ardmore, Pa.

D. M. Seeley: On the design of the lower platen in the quenching press, just how is that arranged to provide the dual functions of feeding plate into the press and also providing back pressure for the hydraulic cylinders coming from the top?

Secondly, are there problems of heating distortion that make it difficult to handle the platen from the standpoints, either of unequal loading on the hardening or normalizing furnace rollers, or distortion that is so extreme as to make it difficult to bring the plate out of the furnace or into the quenching press?

N. K. Willis: To answer your first question, the press is designed with stationary lower platens between the rolls. The rolls are mounted on a hydraulically operated carriage that can be raised or lowered independently of the top ram. After plate enters the press, the rolls go down and deposit the plate on the lower platen as the upper platen moves down on it and applies the pressure during quenching.

You asked if there was any distortion in the plate from the quench. When the plate goes into the press from the hardening furnace, it is absolutely flat because it had been heated to some 1600 F, and when it comes out of the press there is no warpage due to the pressure that maintains the flatness. There are very slight wavers in it sometimes, but it is commercially flat plate. I would say, that the plate 40 ft long and practically 15 ft wide of light gages, that it might be occasionally out of flat by about $\frac{3}{8}$ in.

We have had what you might call "explosions" in the furnace when the plate changes shape during heating, however, it will almost immediately level out as it comes to temperature, and we have had no trouble from that point on that I know of.

Plate is not always flat when it goes in. Some of it has had some previous heating and is in pretty bad shape, sometimes it is out of flat by as much as 10 in. But, as I mentioned, we have had no roll breakage or removal from that furnace. We know very well that in many instances the loading on the rolls has exceeded their design stress but, of course, it was only momentary.

In fact, not too long ago—and I mentioned this explosion in the furnace—where the plate changed shape it came down so hard on the roller it broke a bearing outside the furnace, but did not damage the roll. The plate continued to move on through.

Rolland L. Hoffman: I would like to ask if there has been any effort made to determine whether the design heating times—both the time to temperature and metallurgical soak, having been reduced from what was originally set up—or whether the actual operating conditions are reasonably close to the original design?

N. K. Willis: Yes, efforts have been made. We mentioned the heat treating cycle that we designed for was $2\frac{1}{2}$ hr or 150 min of hardening and $3\frac{1}{2}$ hr for tempering. That is based on 1-in. thick plate.

We do know now that 1-in. plate in the hardening furnace has a complete hardening cycle, that is, heating to temperature and holding or soaking out at temperature of 107 min, right down to the minute—so there is a decrease of some 43 min over our design. The tempering cycle has been decreased on 1-in. plate from 210 min to approximately 150.

Now, that follows pretty much of a straight line of time vs weight until you get up to $1\frac{1}{2}$-in. plate. At $1\frac{1}{2}$-in. to $1\frac{7}{8}$-in., there is a sudden increase in time to get the full treatment. Just why that is, I do not know. Beyond the 2-in., we begin to drop off again in time, and from that sudden increase between $1\frac{1}{2}$-in. and $1\frac{7}{8}$-in., and from 2-in. on up to 3-in., it takes just about the time that we anticipated. In other words, four hours in the hardening furnace and six hours in the tempering furnace.

In fact, I believe on the 3-in. plate they leave it in even longer. The roll speed was set up to give them a minimum speed of 0.6 fpm, but with the type of drive, it is a bit oversize, they can run the d-c motor on down and still have enough motor cooling, and they can get more than four hours in that furnace. I think they probably run it pretty close to five sometimes.

design and construction of Fontana Open Hearth Precipitators

By E. V. AKERLOW, Division Manager,

Engineering Department, Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

▲ AN increasing amount of interest has been displayed by industry in the problem of air pollution control of the various industrial operations in this country. It seems to be a basic consideration that clean air is still one of the freedoms remaining, and to this end the metallurgical industries have been developing methods to control and police air pollution problems as they develop.

The Kaiser Steel Corporation plant is situated in an area that has long been highly conscious of its air pollution problem. The company has been engaged in a comprehensive study of this problem for many years.

San Bernardino County, in which the Kaiser Steel Corporation is located, is adjacent to Los Angeles County, and is contemplating the formation of an air control district. In the interim it adheres to Land Use Ordinance 678 which incorporates the same regulations as employed by the Los Angeles County Air Pollution Control District. These requirements are as strict as any in this country.

As a part of their continuing efforts in air control, the problem of control for open hearth stacks was reviewed and studied by the Kaiser Steel Corporation as early as 1943. Ten years ago the methods of developing accurate data on which to base collection and control equipment design were sketchy and indefinite. Further, the problem had not been studied regarding equipment design and selection because no installation had been completed up to that time.

It may be summarized that the air control and research department of Kaiser Steel studies and reports on cause and effect of various stack emission discharged to the atmosphere. The engineers coordinate design data with these studies to complement the research phase of the over-all program. This provides an excellent development and engineering program and permits the coordination of research to engineering design of the various collection and control devices.

At this time, the nine 225-ton open hearth furnaces are receiving the major share of attention as to equipment installation. The open hearth effluent, principally metallurgical fume, due to its color and opaqueness, appears to be a factor to the air pollution problem in the Fontana area.

. . . . experience with cleaning open hearth gases at Kaiser indicates the best results are obtained with special collecting and discharge electrodes, selenium instead of mechanical rectifiers, specially developed gas distribution apparatus, and the use of wrapping mechanism . . . .

There are now two efficiently functioning precipitator units in the open hearth shop; the first of which was installed on No. 3 furnace and the second, the subject of this discussion, was recently completed on No. 9 furnace. It was our engineers' job to co-ordinate the design with the research and to install this equipment.

This paper will deal with some of the problems of design and construction of an electrostatic cottrell type precipitator as installed on No. 9 furnace. Some of the problems which were solved in this installation may be equally applicable to similar fume control problems elsewhere.

The installation of No. 9 precipitator has, in effect, its roots in No. 3 precipitator. To our knowledge No. 3 was the first such dust control equipment installed on a hot metal open hearth furnace in this country, and many valuable lessons have been learned from its operation. Of the two precipitators presently installed, No. 3 is the smaller in size and handles about 49,000 cfm of open hearth gases at 455 F and 29.92 in. Hg., and is equipped with two sections of special electrostatic fields.

At the time it was decided to install precipitator No. 3, the present air control and research department had not been established. Therefore, the original studies leading to No. 3 precipitator installation, from which design criteria was prepared, was entrusted to an outside independent research organization under our

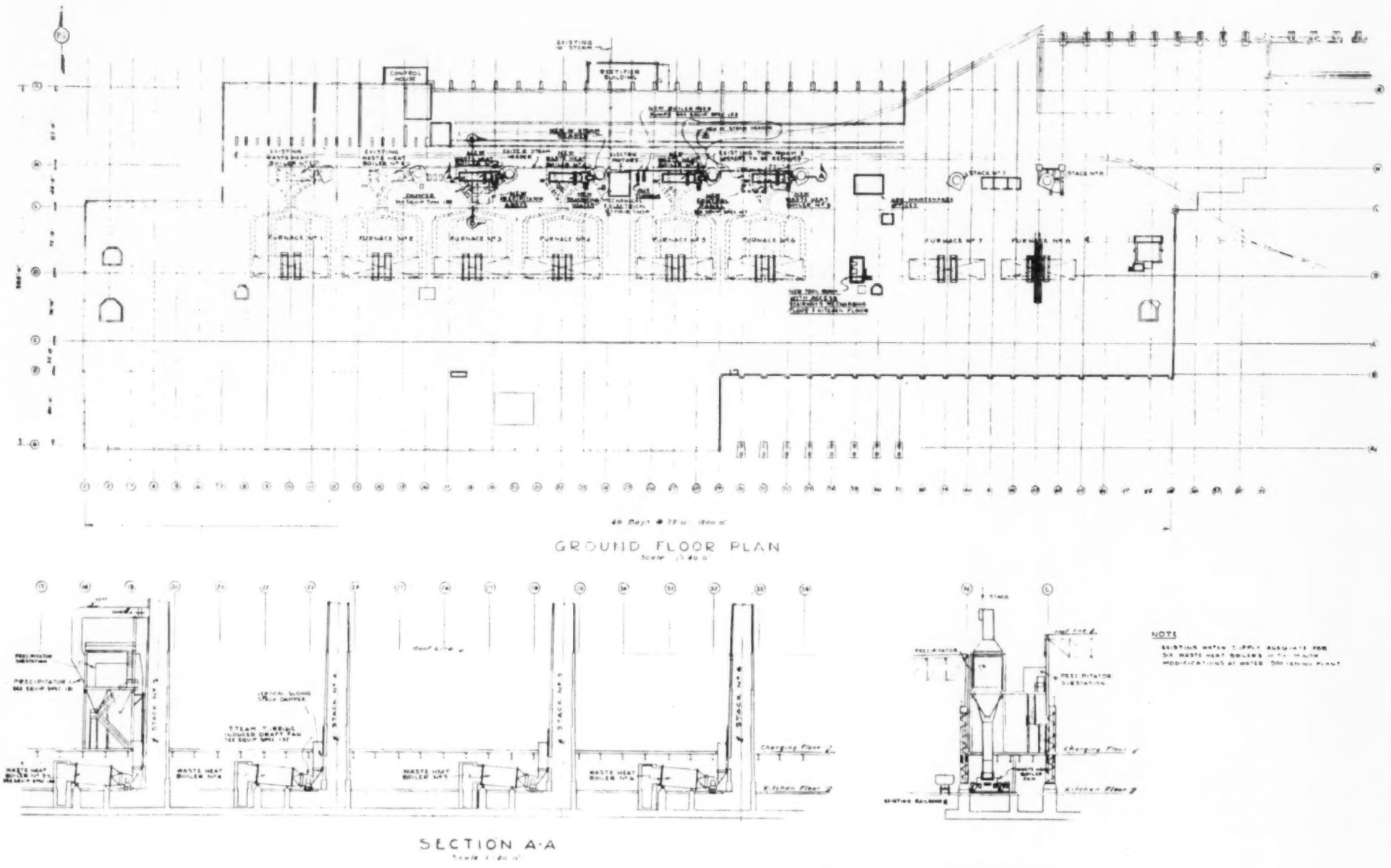


Figure 1—General arrangement of precipitators and waste heat boilers for open hearth furnaces.

direction. As a result of the data gathered at that time, it was indicated that a precipitator at rated capacity and under normal conditions for processing about 74,500 standard cfm at 650 F, and 29.92 in. Hg., and having an inlet grain loading of 1.14 gr per cu ft at 650 F would be required. Waste heat boilers were not installed on all the open hearth furnaces at that time. Therefore, the early proposals recommended that these gases be cooled in a tower designed for this purpose and then taken to a cottrell type precipitator.

Other methods of dust collection, such as gravitational, inertial and sonic equipment were reviewed and abandoned because of high capital cost, and low efficiency when handling open hearth fume. It was also suggested that bag house type collecting equipment could be used after the gas cooler. However, due to lack of water this was abandoned. Specially designed waste heat boilers were installed to reduce the gas temperature going to the collection unit.

One of the interesting points of this installation is that it is possible to bypass the waste heat boiler to the stack, or bypass the precipitator to the stack, or to bypass both units and go directly to the stack.

The problem of maintaining furnace pressure was solved through the use of an oil-hydraulic type control and, at this time, no operating problems concerning maintaining of furnace pressure have developed in the furnaces on which precipitators have been mounted.

No. 3 precipitator is of standard commercial structural steel frame construction and is mounted on columns supported off the kitchen floor of the open hearth.

It developed that the basic criteria as to gas volume and dust loading was substantially correct. At times of a boil in the furnace, however, the characteristics of the dust and fume change, the gas volume increases along with the temperature, and these conditions were carefully studied. These studies indicated that modifications be made in the precipitator to correct its malfunctioning.

This precipitator employed a pocket-type collection electrode which was developed to prevent, during the rapping cycle, as nearly as possible, particulate reentrainment in the gas stream.

The unit was originally designed with two electrostatic fields, each twenty ducts wide; and about nine feet long. Rapping of the collecting and discharge equipment was accomplished with conventional air hammers mounted within the precipitator shell, these were actuated by stainless steel piping attached to the rapping cylinders. Air was supplied from the plant compressed air system at 80 psi.

The distribution plate at the entering and discharge end of the precipitator consisted of a single flat punched plate. The gas speed through the precipitator was in the order of magnitude of 4 fps. This led to a problem of gas distribution within the unit, and affected collection of the electrostatic fields.

Operating problems were carefully studied for approximately nine months. Pilot units were installed to determine why the prototype would not function as designed. As a result of these tests apparently the most important operating problems were:

1. The strengthening and reinforcing of the precipitator and supporting structure to prevent vibration and shaking within the unit caused by movement of cranes, trains and similar equipment in the open hearth building.

2. The turbulent and erratic flow of gas entering the precipitator required correction.

3. Modifications of design of the gas distributing devices within the precipitator proper were required to improve gas distribution.

4. Residence time of the gas within the precipitator was insufficient.

5. Low voltage and inadequate control of the connected energy to the discharge electrode system required improvement.

6. The sequence and type of rapping which permitted excessive dust build-up should be modified.

Each of these items may be considered as having a major bearing on the design of equipment for collection of the fume of the type encountered as emitted from a hot metal open hearth furnace.

Basically the changes made in No. 3 precipitator consisted of:

1. Installation of curtain type electrodes.

2. The installation of gas distributing baffles entering the precipitator.

3. The reworking of the rapping mechanism.

4. The development of gas flow testing devices using hydraulics as a media. The installation of pilot electrostatic precipitators to obtain operating and performance data. These studies also included the cause and effect of gas conditioning upon the collecting ability of the precipitator.

5. The redesign of the electrical control.

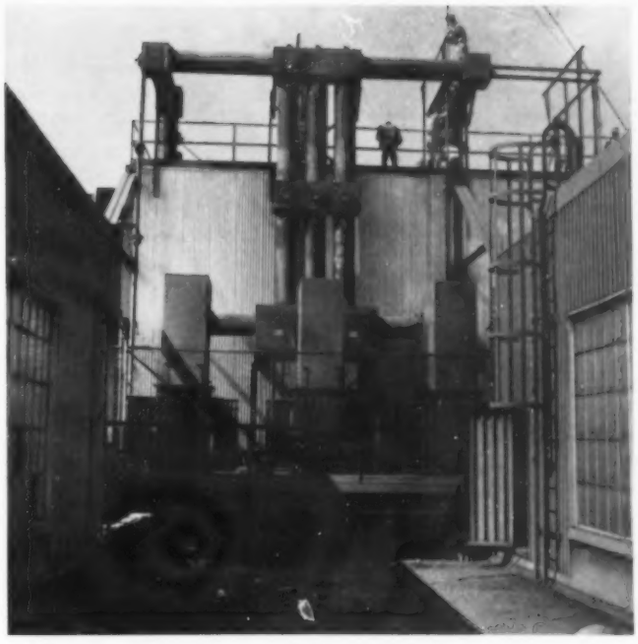


Figure 2—Equipment was installed in stack aisle between the stock house and furnace charging areas.

DESIGN OF NO. 9 PRECIPITATOR

When the operating criteria was established for the effluent from No. 9 furnace, it was a difficult task to design equipment to meet these conditions with a

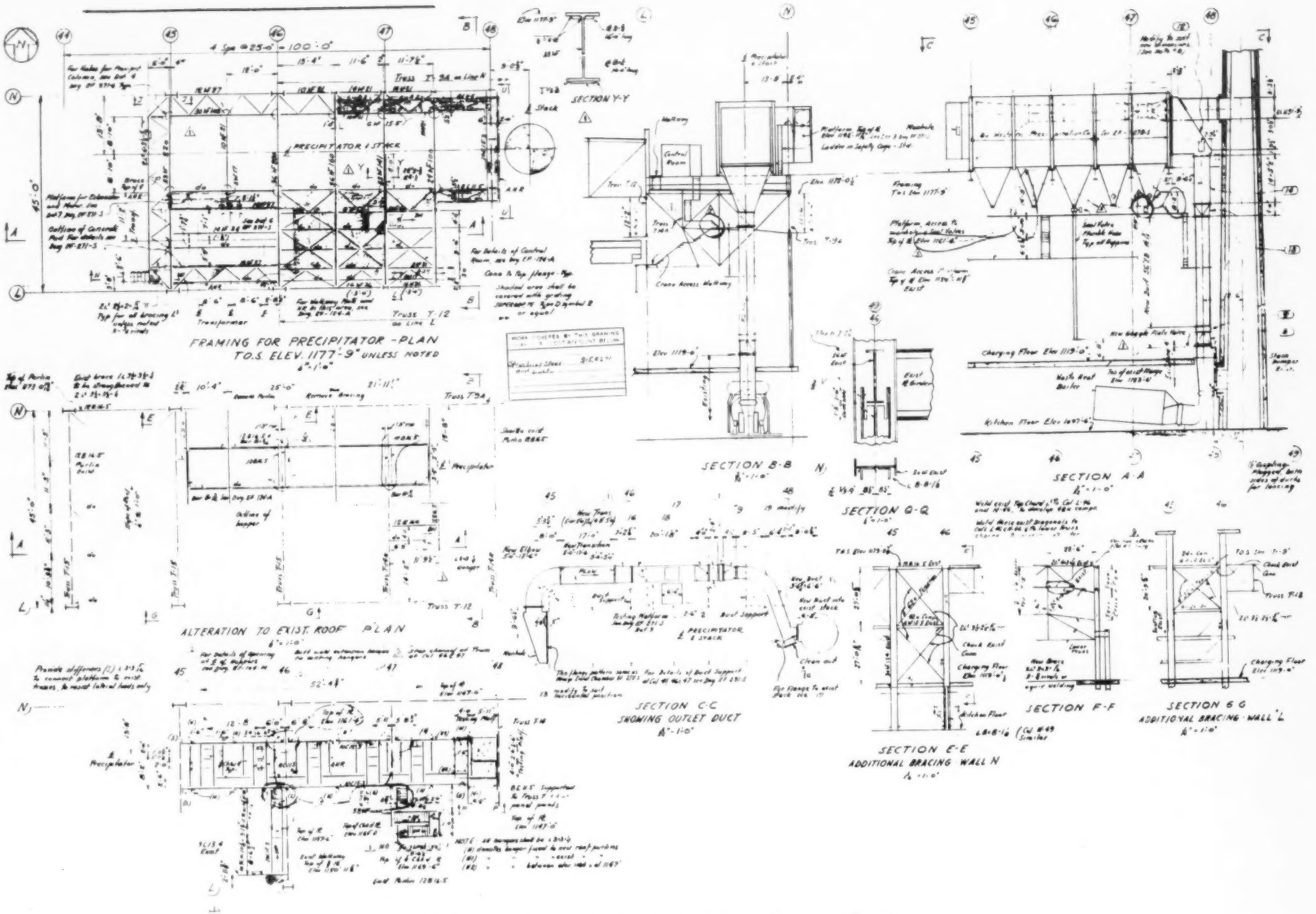


Figure 3—Columns supporting precipitator shell were stiffened.

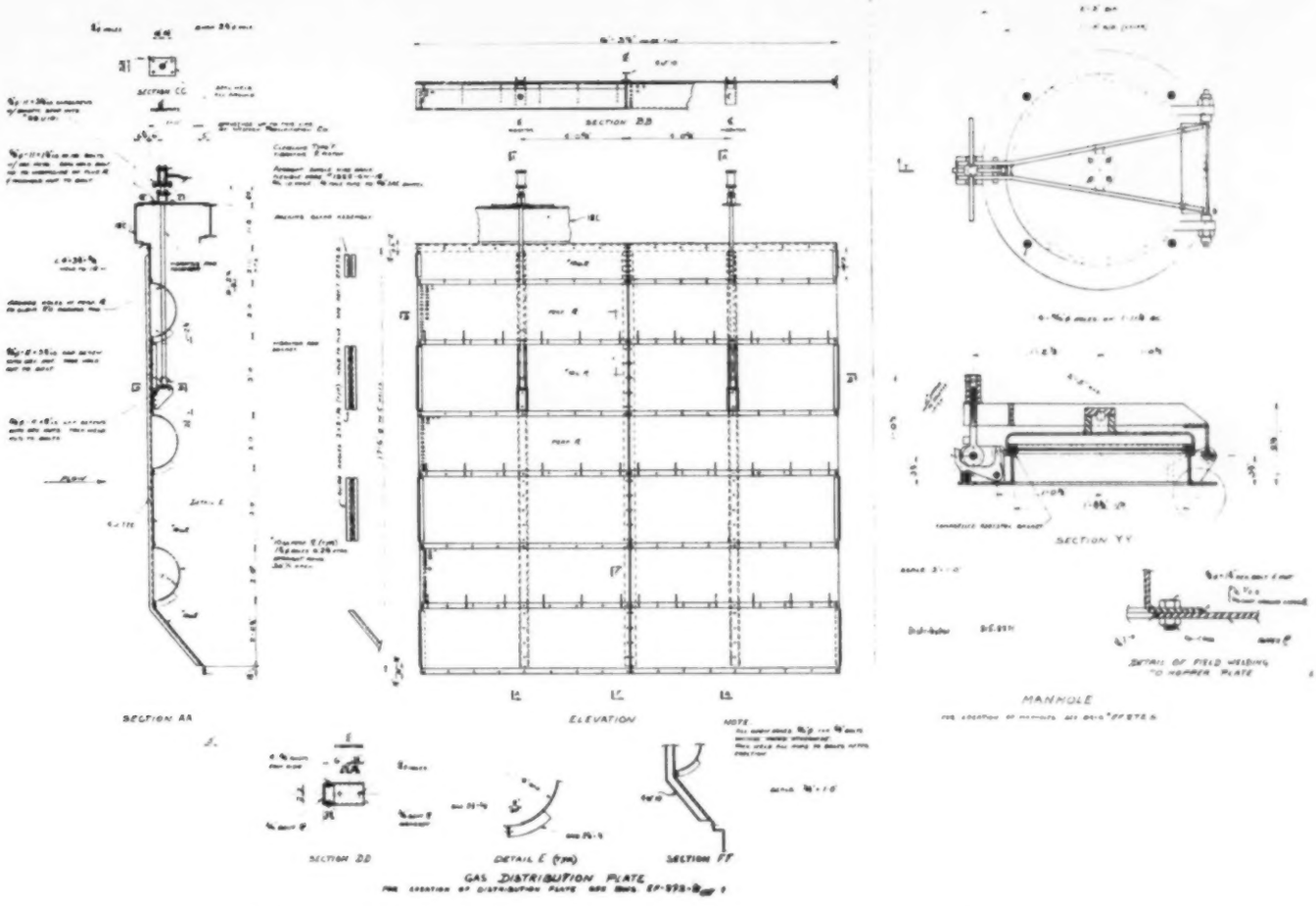


Figure 4—The distribution plate is placed just ahead of the electrostatic field.

minimum of capital outlay and operating costs. Following the basic intent of conserving floor space wherever possible and yet provide a trouble free operating installation, the roof area of the open hearth shop adjacent to No. 9 stack was selected as the best space for installation. The original design of the open hearth buildings did not anticipate the installation of any equipment on the roof. The reason for moving the unit off the charging floor was to get away from vibration within the unit and to isolate the installation providing more adequate servicing and maintenance and, also, to obtain sufficient height to remove efficiently the dust collected in the unit. The problem of mounting the precipitator on the open hearth roof became one of developing a design that would not shake or vibrate the unit with the passage or movement of cranes, charging machines, or other equipment in the open hearth shop.

The equipment was installed in the stack aisle which is between the stock house and furnace charging areas. We found that the steel columns above the craneways in these two areas had a lateral movement at their highest point of about 1 to 1½ in. The stack aisle of the open hearth building is approximately 40 ft wide and 1,200 ft long. To resolve the forces of the 70-ton precipitators, the aisle was divided into four equal areas, and each was analyzed to determine the residual strength of each area. When earthquake bracing is considered, and considering the height at which the precipitator is mounted, it becomes a difficult task to install structural steel at the elevation required to withstand the forces that could be applied to it. The area unit selected was then checked against the new imposed loads and stiffening was added where required. The top chord plan of the open hearth roof was also reinforced where necessary for the added loads to be imposed.

Future expansion, that might require additional electrostatic fields to the unit, was considered in the over-all reinforcing of the building structural frame as well as the precipitator shell.

DESCRIPTION OF PRECIPITATOR

As installed, the precipitator resembles a rectangular tube with a width of 17 ft-8 in., an over-all length of 59 ft-8 in. from gas inlet to gas outlet, and a height from the dust outlet hopper to the top of the high voltage terminal housings of 43 ft-4 in. It is designed to handle 58,500 cfm of dust laden gases at 460 to 470 F and 29.92 in. Hg. The moisture content of the gases entering the precipitator shall range between 8 to 12 per cent by volume. The average inlet loading shall be 0.43 gr per cu ft at normal operating conditions. The pressure drop or draft loss permitted between the inlet and outlet is 0.5 in. of water. The structural steel support of the precipitator is designed to be integral with the precipitator shell structure.

The strengthening and reinforcing of the precipitator

was necessary since it had been determined from previous tests and operating data that commercial precipitators, as presently manufactured, are too light in design for the extremely heavy duty required in open hearth service. The columns supporting the precipitator shell were stiffened together with the hanging mechanism carrying the discharge and collection electrode systems.

The discharge and collection electrode systems were strengthened to resist the rapping cycles which are considerably heavier than currently practiced in conventional precipitator design. The precipitator reinforcing is important because vibration or movement within the precipitator must be kept to a minimum, since this vibration, or shaking of the discharge or collecting electrical sections, would cause arcing and short the electrical system.

The dust hoppers were provided with round corners, and the openings at the bottom of the hoppers were enlarged to permit freedom of movement of the dust. When square corners or shelves were found to cause dust build-up, they were removed by placing a round steeple over them. The method of removing dust from the hoppers is another subject and will not be discussed at this time.

In our early studies, we determined that the flow of gas entering the precipitator is very important, as well as its distribution within the precipitator proper being extremely important in maintaining maximum efficiency at all times. The distribution section ahead of the electrostatic field was provided for the following three reasons:

1. To give the gas an opportunity to slow down and to reduce turbulence as much as possible.

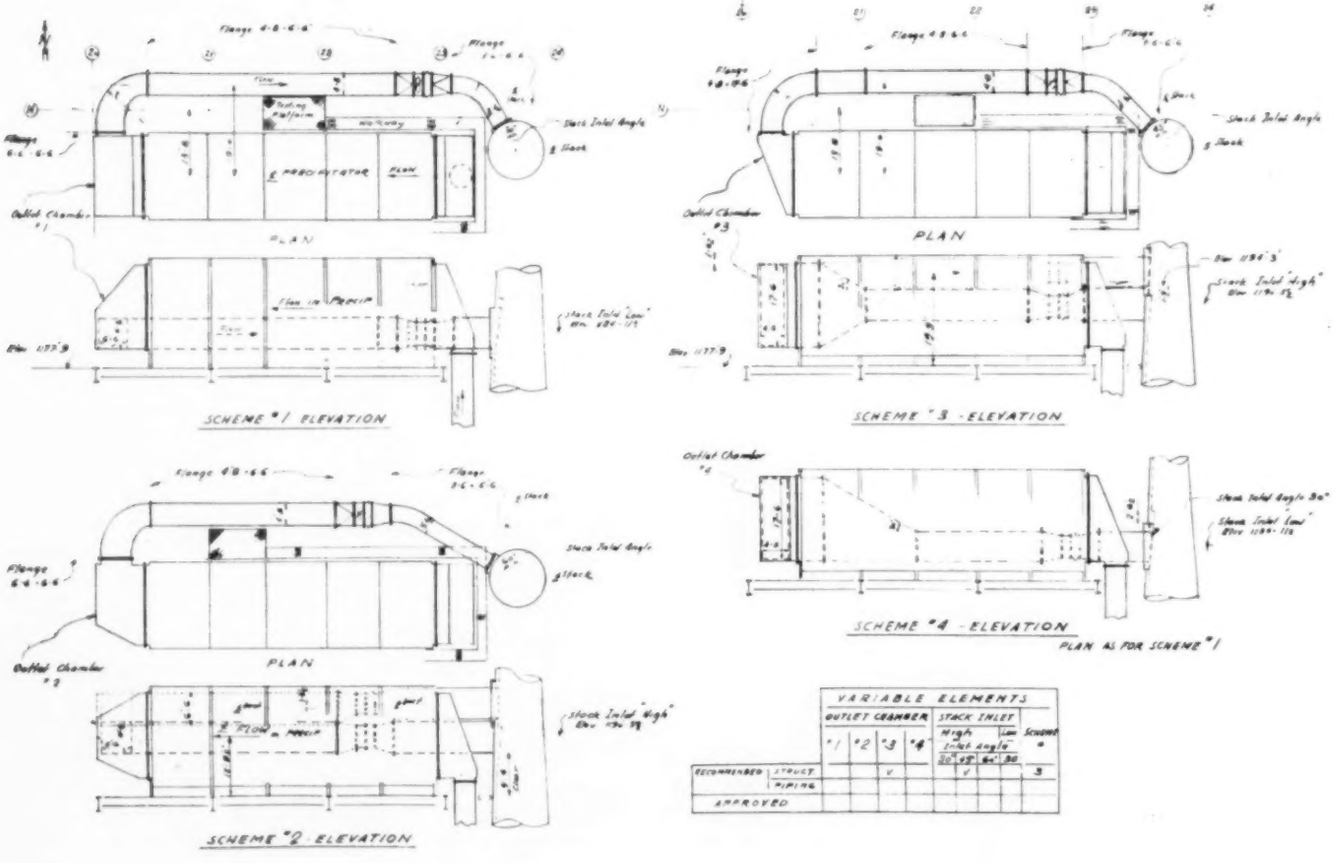
2. To check out any extremely heavy particles of material in the gas stream caused by blowing checkers or boiler tubes.

3. To provide space in the event it became necessary to add additional electrostatic fields to the precipitator to gain a greater collection than is possible with the present unit.

The entry of the gas into this first section was through a specially designed duct with baffles placed in it in such a manner that it would reduce turbulence to a minimum, and cause the gas to flow over the entire area of the entering section of the precipitator. At the end of this section and just ahead of the electrostatic field, a distribution plate was placed consisting of three curved, perforated baskets extending across the width of the precipitator. These baskets are mounted in such a manner as to provide uniform flow through the electrostatic field. This innovation was reached after several months of study with a water model and is one of the major contributions in this field. The design of gas distribution equipment within the precipitator proper also included baffles placed between the electrostatic fields and at the bottom of these fields. The baffles keep the gas from short-circuiting down into the hoppers and also maintain a relatively uniform flow through the duct work of the electrostatic fields.

At the outlet end of the precipitator an additional flat, perforated plate was installed to keep the gas from short-circuiting to the outlet duct. Several designs were studied in the outlet duct, but the one selected appears to be the most practical and is being improved upon in current installations.

Figure 5 Sketch of duct layout.



From an operating point of view there are advantages still to be gained if a little additional straight duct section could be added to the outlet. To keep the distribution equipment clean, soot blowers were provided to clean the openings in the perforated baskets and to remove dust build-up in the outlet duct. These distribution systems have also been equipped with rappers.

The residence time of the gas in the electrostatic field is related directly to distribution and over-all precipitator efficiency. It had been found that effective collection at the temperatures indicated may be obtained with a gas flow of approximately 2 fps. A flow of 4 to 6 fps is considered too high and reentrainment of the collected dust at this value creates an operating problem. When the fume changes from a metallurgical type to an alkali type—such as is encountered in a lime boil—our attention has been directed towards the increase of power in the unit to aid further in collecting this type of particulate. During the hot metal charge to the furnace, the more than normal sparking—which is associated with good precipitator performance—was analyzed, and automatic control of the input voltage has been carefully reviewed to develop higher potential on the discharge electrodes at those times. At the present time, the electrode system is not equipped with this type of control, however, this is being considered. It is important that the arc in the precipitator, during these high-grain loading conditions, be quenched as quickly as possible. It is anticipated, at this time, that the proposed automatic control will correct the arcing problem. The No. 3 precipitator had the conventional mechanical rectifier equipment. No. 9 precipitator was designed to employ saturable reactor control with selenium rectifier transformers. While first cost of selenium rectifiers is more expensive than mechanical rectifiers, it has many inherent operating advantages. It maintains a higher rms voltage in the precipitator permitting improved precipitator operation.

The sequence and type of rapping is important to best precipitator performance. The unit was originally equipped for external rapping of the collecting curtains. The rapping for the discharge electrode system was within the precipitator and was connected to the external air service through stainless steel tubing. The two systems were originally scheduled to operate automatically on 1½-hr intervals. We have learned that under certain conditions, the fume has a tendency to be oily in nature causing build-up on the discharge electrode frame work and on the collection frame work as well. Sometimes the dust, as collected, would sinter and no amount of rapping would remove it. In No. 9 precipitator, the discharge electrode frame was designed to be one complete self-supporting and rigid unit. The rapping of this equipment was handled through outside rappers mounted on insulators which, in turn, are mounted in an air-cooled chamber. This has eliminated the problems of build up, and keeps the precipitator relatively clean which will reduce corrosion and improve precipitator performance.

The collecting curtain system is similarly supported. The rapping cycles have been cut to 30 or 40 minutes, and when extremely dirty material has been charged to the furnace, it may be manually rapped from the

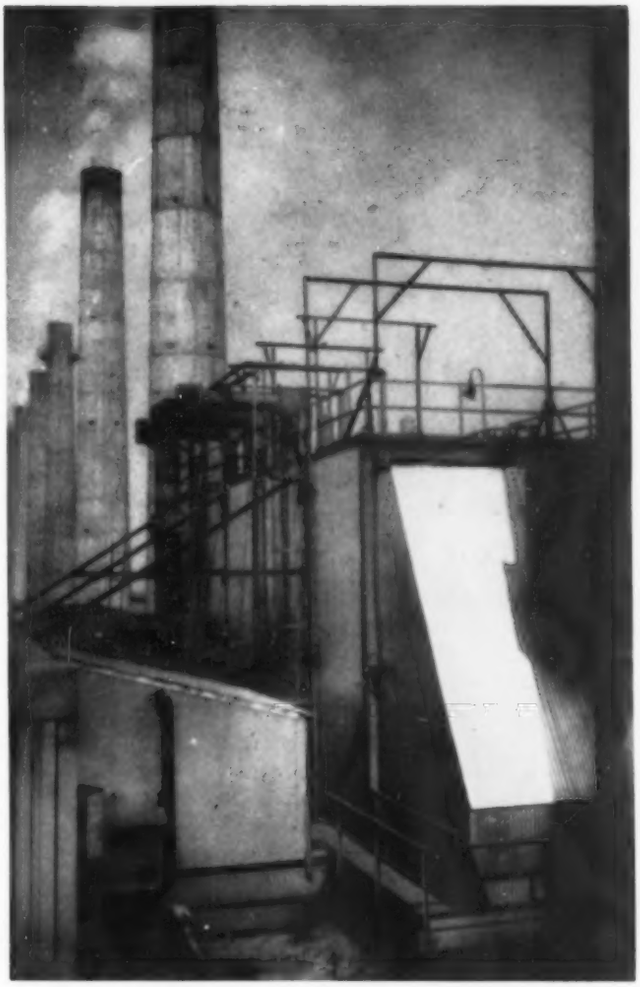


Figure 6—Precipitators at Fontana are operating with an outlet grain loading of about 0.025 grains per cu ft.

operating floor of the open hearth. It is essential that the dust removal from collecting and discharge electrodes be accomplished as quickly as possible after it has built up and the time limit indicated for our gas appears to be the most effective. In connection with rapping, the gas flow value previously mentioned becomes important.

The rapping is a sharp, hard blow of substantial intensity, and each blow is perhaps two seconds apart. This is a much better type of rapping for open hearth fume rather than a series of short frequency blows, because the latter tends to pack the dust upon the collecting curtain.

A problem of condensation within the precipitator proper was corrected by the installation of light weight insulating aggregate concrete on the roof of the precipitator with a ferrule embedded around its perimeter. The insulation on the precipitator proper was a blanket type material, covered with an aluminum sheet properly flashed to the ferrule reglet on the roof perimeter. The hoppers, since they extend below the roof line, were not insulated and the dust within them provides this insulation.

The control house for the precipitator is of conventional design, provided with adequate air cooling, and is as close to the precipitator unit as possible to reduce line losses and corrosion of power cable.

The inlet and outlet duct to the precipitator is

equipped with expansion joints of the spun bronze type, otherwise the unit is as completely rigid as possible.

Installing the precipitator in an outside mounting in this fashion also eliminates the installation of concrete control houses and transformer houses, since with an outdoor installation, it is possible to use a tray on which the transformers may be mounted. All hatches in and around the precipitator proper have been designed for easy access.

After a unit has been installed, and prior to its acceptance, certain tests are required. The Kaiser Steel Corporation has developed, in conjunction with this testing period, methods and procedures as well as equipment that are now being considered by the industry as important to more accurate results. It is possible that some of these will be accepted standards soon.

Electrostatic precipitators for use on open hearth furnaces should not be purchased on price alone. Many of the hidden values indicated here are not on the average price tag, and will spell the difference between poor performance and good operation, low maintenance and long life.

The precipitators at Fontana are now operating with an outlet grain loading in the neighborhood of 0.025 gr per cu ft, and actually emitting between six and eleven lb of particulate to the atmosphere per hour. The average amount of particulate entering the precipitator is about 160 lb per hr.

This report has outlined some of the key points that are reflected in the design of open hearth No. 9 precipitator. They are being carried forward in the current installation of precipitators 4 and 5.

The contribution made with this installation consists of basic data of value to the trade as a whole. The use of selenium rather than mechanical rectifiers, special collecting and discharge electrodes; the application of rapping mechanisms; and the development of gas distribution apparatus are among the most important.

DISCUSSION

PRESENTED BY

J. R. GILLESPIE, General Supervisor, Power and Fuel Engineering, Geneva Works, United States Steel Corp., San Francisco, Calif.

R. G. GAW, Manager, Pittsburgh Office, Western Precipitation Corp., Pittsburgh, Pa.

E. V. AKERLOW, Division Manager, Engineering Department, Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

J. R. Gillespie: Mr. Akerlow's paper substantiates our experience and thinking in the following respects:

1. Design to provide uniform gas distribution and low velocities in the precipitators in order to reduce re-entrainment of dust in the gas stream.

2. Having the rapper or vibrator mechanisms outside the gas stream facilitates making adjustments, proper maintenance and better control of build-up on plates and discharge electrodes.

3. Frequent rapping of plates and vibration of high tension electrodes to dislodge collected dust to prevent excessive build-up inside the precipitator.

4. Selenium rectifiers definitely have the advantages mentioned by Mr. Akerlow.

There are two other points I would like to bring out which should be considered in building precipitators for an open hearth shop.

1. The installation of a collector main into which all the gases from the waste heat boilers can be discharged and blended with each other before entering the precipitators. The advantages of this type installation are: (a) a more uniform gas and fume quantity and quality, (b) reduce precipitator size by designing for maximum shop gas volume instead of designing for individual maximum furnace volumes, and (c) the increased adaptability of this design which becomes apparent when one considers that a precipitator on one end of the collector main could be out of service at the same time as a furnace on the other end of the collector main. Under these conditions, it would still be possible to handle all the waste gases in the precipitators. (The idea of the collector main principle might be investigated for installation ahead of the waste heat boilers in future shops or in older shops that are adding waste heat boilers.)

2. Splitting the individual precipitators into multiple precipitating units of two or more sections in series so arranged as to provide at least a double pass or double contact of the gases with sections powered from different transformers. This in effect provides multiple cleaning which is desirable in high efficiency gas cleaning.

R. G. Gaw: Will the author explain how the vacant section of shell provided ahead of No. 9 open hearth cottrell precipitator would be utilized for additional precipitator capacity, if in the future the open hearth practice would include roof blowing with an oxygen lance? Further, what is his appreciation as to how effective this additional capacity would be in maintaining the same outlet gas cleanliness if it were installed for oxygen blowing practice?

E. V. Akerlow: Regarding the discussion by Mr. Gillespie, there were two reasons why we did not consider multiple precipitator installations at the Fontana plant: (1) increased capital cost, due to the gas main installation, and (2) the problem of keeping the duct clean.

Regarding the comments by Mr. Gaw, the vacant section of the shell provided ahead of the Fontana precipitator will receive additional electrostatic fields, in the event we increase the grain loading with oxygen lancing of open hearth furnaces.

The second question having to do with the efficiency of this possible future expansion was considered carefully in the light of knowledge then available. Studies since tend to indicate that while the fume itself may be more opaque, due to the small particle size, we believe that precipitator efficiency will not be materially affected.

Regarding the subject "gas cleanliness," I can only point out that when viewing a fume from any stack, it depends entirely on where you are viewing the fume emanating from the stack as to whether or not it appears clean or dirty, which is one of the big problems in education of enforcement officials.

. . . . careful testing is required to actually determine true cleaning efficiency of open hearth precipitators . . . . continuous sampling methods are required, a dry method of cleaning probes is necessary, "ashed" method of weighing thimbles is more convenient, and use of computing machines saved many man-hours . . . .

Method of Testing Open Hearth Precipitators

By
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and
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▲THIS paper will deal only with the methods and equipment used to test the efficiency of the precipitator installed on Kaiser Steel Corp.'s number nine open hearth furnace. It is believed that the testing program conducted on the precipitator on number nine open hearth has provided a great deal of useful information which can be incorporated in the testing of future installations. Each refinement in testing procedures provides the engineer with a more accurate gage by which the effect of modifications or experiments in precipitator design can be measured.

Several innovations were incorporated in this installation which had not been used in the precipitator on the number three open hearth furnace. It should be remembered that each of these installations involves a number of organizations, each vitally concerned with the performance of its particular portion.

As a result of the experience gained through testing the performance and efficiency of the previous installation, the new program was designed to provide as comprehensive data as possible. It was further agreed that all interested parties would assist in the testing and collection of data. Western Precipitation Bulletin No. 50 served as an outline. Each step was then approved or modified to meet the demands of all concerned. In some instances, it was necessary to obtain two sets of data using different methods, and/or equipment. However, in spite of the divergencies, it is a pleasure to report that a spirit of complete co-operation and understanding existed throughout the test period.

The vending company's guarantee stated that when the precipitator on number nine open hearth furnace was installed, adjusted, and operated within its rated capacity and under normal operating conditions, the suspended solids contained in the exit gases leaving the outlet flue system of the installation would not exceed 5.0 per cent of the suspended solids present in the gases entering the inlet system of the installation. However, the vendor included an option stating that a dust concentration of 0.048 gr per cu ft or less at 450 F, in the outlet gases would be deemed to satisfy the guarantee.

It was also agreed that the percentage of entering suspended solids discharged to the atmosphere would be calculated from the measurements of any two of the following quantities:

1. The suspended solids entering the inlet flue system of the unit as determined by measuring the weight of suspended solids contained in the gases entering said inlet flue system.
2. The suspended solids collected by the unit as determined by measuring the weight of all suspended solids collected between the point where the gases enter the unit and the point where the gases leave the unit (i.e., hopper catch).
3. The suspended solids discharged to the atmosphere through the outlet flue system of the unit as determined by measuring the weight of suspended solids contained in the gases leaving the outlet flue system and discharged to the atmosphere.

The rated capacity and normal operation conditions were described as follows:

Gas volume:	58,500 cfm
Temperature:	460 to 470 F
Pressure:	Between 1-in. positive and 1-in. negative static pressure vertical water column (normal barometer 29.92 in. Hg)

Moisture: 8 to 12 per cent by volume
Suspended solids: Open hearth dusts and fumes averaging 0.43 gr per cu ft at normal operating conditions.

The above conditions formed the basis upon which the testing program would necessarily be conducted.

FLOOR DATA

During each test an engineer was stationed on the charging floor to record all data pertinent to that particular heat. For example, he recorded rate of fuel consumption, air flow, furnace pressure, periods of the heat, additions to the furnace, the number of furnace doors open and at what times, the characteristics of the slag, plus any information which he felt might have a bearing on the test. In addition to the above, the charging floor engineer coordinated all testing activities by telephones positioned at each testing site.

DETERMINATION OF FLOW

A. Velocity distribution within the precipitator—The first step in the program was to determine gas flow patterns through the precipitator. The fact that low velocities and high temperatures were factors to be considered, presented minor problems. Such a combination of conditions necessitated very delicate instruments capable of standing the high temperatures. As a result, it was decided to use a rigid type pitot tube, twenty-three ft in length, connected to a draft gage having a sensitivity of 0.001 in. of water with a range of 0 to 0.1 in. of water.

Considerable difficulty was encountered through vibrations caused by precipitator rapping and crane movement in the open hearth shop. However, this was solved by mounting the draft gage on a camera tripod having rubber cushioned legs. Our tests indicated that the distribution, within the precipitator, was quite satisfactory.

B. Velocity determination in outlet flue—While the distribution was being checked other personnel were testing the mechanical and electrical parts of the installation. The tests revealed that all parts of the unit were operating properly. The next step in the program was to determine just how effectively the precipitator was working.

However, before any samples could be obtained, it was necessary to determine the gas velocity distribution within the flues. This was accomplished by use of a standard pitot tube and inclined draft gage. Since the outlet flue was rectangular, it was necessary to make velocity traverses along two dimensions. It was decided that the testing locations in this duct would be fitted with 4-in. pipe couplings welded to the top and one side of the duct. When not in use, the couplings could be sealed with standard pipe plugs. The couplings were so positioned on the two surfaces of the duct to provide access to nine equal areas across the duct.

C. Velocity determination in the inlet flue—Since the program demanded dust load concentrations from both the inlet and outlet flues, velocity determinations similar to those made on the outlet flue were also made on the inlet flue. However, in this instance, the flue was a circular duct. Two sampling ports, separated by 90 degrees, were provided in this duct. An additional port was provided permitting the engineers to monitor the stack temperatures.

SAMPLING METHOD AND EQUIPMENT

The sampling equipment consisted of a standard sampling probe with removable nozzles. The nozzles could be changed to cope with different gas velocities. A standard condenser, meter, and air pump were also incorporated in the sampling train.

It might be of interest to note that the isokinetic or "null" type nozzle was not used. Several different designs of isokinetic nozzles had been tried and in each instance, were found to be unsatisfactory. In view of this, a monitoring pitot tube was used in the gas stream near the sampling probe at a point at which the velocity had been previously determined and which velocity had a known relationship with that at the sampling point.

Since the flow in an open hearth system fluctuates considerably, it was necessary to incorporate some device for determining the sampling rate in place of measuring the volume over a given length of time on a standard gas meter. This fluctuating condition was most pronounced in the inlet system. The engineers incorporated a calibrated orifice in the sampling train which read directly in cubic feet per minute. The use of this rate meter permitted rapid changes in the sampling rate, closely following the flow through the system.

Particulate matter was separated from the gases by using standard paper thimbles. In order to prevent condensation on the thimble, the thimble and the thimble holder were preheated and kept above the dew-point while sampling. Prevention of condensation in the thimble is necessary since the "weigh-back" becomes inconsistent and unusually high due to dissolved salts in the condensate which do not evaporate upon drying the thimble. Again, wet thimbles become weak and break.

The thimbles were tared before use in accordance with standard procedures. However, the "weigh-back" was found to be quite erratic. As a result, two methods were used to ascertain the dust collection on the "used" thimble. The first method incorporated an original tare before use, and a subsequent drying period, and standard "weigh-back" after use. The second method consisted of ashing the used thimble, weighing the ash, and deducting an appropriate amount for the thimble ash. The thimble ash weight was determined by taking two thimbles, at random, from each box and weighing, ashing, and then weighing the ash. The average ash weight per gram of original thimble weight was then considered as representative for that box of thimbles. The thimbles were ashed at 480 C for $3\frac{1}{2}$ to 4 hr.

Three probes, each with a condenser, meter and air pump, were used in sampling the outlet flue. Each probe was traversed over the entire cross section of the duct to obtain a representative sample of the particulate-laden gas stream. From previous studies, this technique was found to be mandatory in sampling a system having a non-uniform velocity distribution curve.

The inlet flue samples were obtained by using two sampling trains and traversing alternately across the diameter of the circular duct. The duct was divided into equal area rings and samples obtained from each of these areas.

The condensates (from the condenser) were measured and calculated back to water vapor volume. This calculated volume was then added to the meter reading for each sample.

INLET VERSUS OUTLET

Using the formula: $\frac{\text{Inlet} - \text{Outlet}}{\text{Inlet}} \times 100 =$ per cent efficiency, the precipitator's efficiency can be determined. This formula assumes that the difference between the inlet concentration and the outlet concentration will provide the actual weight of material collected by the precipitator. Using this method, the unit maintained an average efficiency of 94.3 per cent over the entire test period.

OUTLET VERSUS PRECIPITATOR CATCH

By using the formula: $\frac{\text{Hopper Catch}}{\text{Hopper Catch} + \text{Outlet}} \times 100 =$ per cent efficiency, the precipitator's efficiency can again be determined. The outlet dust concentration was calculated in pounds per hour, while the hopper catch was actually weighed at the end of each test period and pounds recovery per hour calculated therefrom. Experience indicates that it is difficult to obtain an absolutely clean hopper. However, it was found that if a number of tests were made consecutively, the error would be minimized, and an average could be determined for the entire period.

The results indicated that, using this method, the precipitator maintained an average efficiency of 94.7 per cent during the test period. Here we must assume that hopper catch plus outlet concentration will provide the actual inlet concentration.

The results of the two methods indicate that if one samples continuously, either of the above methods may be used to determine precipitator efficiency. It will be noted that a variance of 0.4 per cent existed between the methods.

With respect to the "direct" vs. "ashed" method of weighing the thimbles, it was found that the "ash" method consistently gave higher efficiency values; however, the difference was not significant. The maximum deviation between the two methods was 0.8 per cent. It is our considered opinion that the "ashed" method is more practical in open hearth testing than the "direct" method. The laboratory technique need not be quite as exacting when weighing the ash as it must be when weighing a hygroscopic thimble and dust.

METHOD OF CLEANING PROBES

In any sampling method it is essential that the sampling probes be thoroughly cleaned after each test if one expects to obtain good and consistent results. It was not possible to use wet methods in these tests due to the solubility of the particulate. A dry method, therefore, had to be incorporated for cleaning the probes. The method adopted incorporated a standard shotgun cleaning rod with an appropriate sized brass bristle brush. All material within the probes was brushed and wrapped into the thimbles before the thimble holder was detached from the probe.

USE OF DATA

The data sheets were so arranged that all data compiled at the testing stations, in the laboratory, as well as the final calculations (made by the statistical technician) could be entered on them. After the laboratory had made the appropriate weighings and entered same on the data sheets, the statistical technician made all calculations, and entered the results of the efficiencies, dust loadings, and dust emission rates on the original data sheets. The sheets were then duplicated by the ozalid process and assembled into book form. Each participating group thus received a copy of all original data.

CALCULATIONS

Those who have conducted sampling from flues or stacks are well acquainted with the voluminous calculations involved in obtaining flows through the use of pitot tube measurements. In order to expedite the efficiency determinations, flows and velocities were calculated through the use of IBM machines. This procedure was found to be most expeditious. In order for the IBM machine to be used effectively, a system of code numbers was incorporated for each position within the flue at which velocity determinations were made. The inlet duct data were separated from the outlet data by means of an additional prefix number. Once the code numbers for these positions were set up, the IBM machines could provide any combination of sums or averages within a few minutes. Thus, the engineer's work in obtaining velocity distribution curves was resolved to obtaining the data from the stations and plotting the information provided by the IBM machines. The time and labor saved through the use of these machines was tremendous. However, it was still necessary for the statistical technician to calculate some of the averages and put the data into meaningful form after their return from the IBM machines.

SUMMARY

It is the opinion of all participants that the data collected has proven most significant and will be reflected in the designs of future installations.

DISCUSSION

PRESENTED BY

R. G. GAW, Manager, Pittsburgh Office, Western Precipitator Corp., Pittsburgh, Pa.

R. G. Gaw: The authors should be complimented for their refinements in open hearth precipitator testing techniques developed at Kaiser. The thoroughness with which these tests were performed has proven Kaiser Steel's interest in accurately gaging their precipitator efficiencies. It is of interest to note that they mention that continuous sampling methods are required for precipitator efficiency determinations.

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Pictorial Roundup

AISE

Spring Meeting

Netherland Hilton

Cincinnati, Ohio

April 29, 30, May 1

The AISE board of directors, district secretaries, and members of the staff (1) attended a dinner April 28 preceding the semi-annual business meeting which attracted a total of 819 registrants, some of which are shown in (2).

Seven technical sessions highlighted the first two days of the meeting. Among those participating were: rolling mill session (3) Louis Moses and R. C. Schaefer (seated), K. A. Eck, E. C. Peterson, H. E. Muller and H. J. Kalberkamp; in electrical session (4), A. F. Kenyon, H. J. Oakes, R. G. Nolan, E. L. Anderson (back to camera), D. C. McCrady and R. A. Phillips; in rolling mill session (5) C. S. Lambert, W. V. Magee, E. E. Davis, W. H. Mulflur, and F. G. Kredel. Shown in (6) are members of the combustion session: (seated) F. R. Pullen, R. A. Lambert, J. Leo Hagan; (standing) H. A. Kuhne, F. B. Bevelheimer, and T. E. Dixon; in rolling mill session (7), G. E. Kennedy, F. Slamar, R. P. Schuler, H. S. Orr and R. J. Barry; in mechanical session (8), George Sackerson (back to camera), F. W. Zurn, W. G. Ritter H. R. Knust and C. H. Good, Jr.

E. L. Anderson, superintendent electrical dept., Bethlehem Steel Co., Johnstown, Pa. (9) is shown as he presented his paper, "Electrical Equipment for a Modern Rod Mill," and H. J. Kalberkamp, chief engineer, Mesta Machine Co., is pictured (10) presenting his paper, "Recent Developments in Slabbing Mills."

The first portion of the off-the-record rolling mill panel discussion (11) covered guide application and materials on rod and merchant mills. Participating were: D. C. Horsman, R. H. Custer, Robert Gourlay, M. T. Magee, A. H. Griffiths and C. S. Lambert.

Typical of the well-attended sessions is the group shown in (12).

R. L. Gray (13), president, Armco Steel Corp., chats with J. D. O'Roark, AISE president, at the reception for the speakers' table guests, which preceded the informal stag dinner April 30.

Also at the reception (14) were A. P. Miller, vice president, Acme-Newport Steel Co., F. H. Fanning, vice president-operations, Armco Steel Corp., and H. V. Clark, executive vice president, Detroit Steel Corp.

An address by R. L. Gray followed the dinner (15).

An inspection trip to Detroit Steel Corp. (Portsmouth, Ohio plant) on Wednesday, May 1, concluded the three day meeting. In (16) AISE registrants are shown leaving the open hearth shop while in (17) they watch the 44-in. blooming mill in operation.

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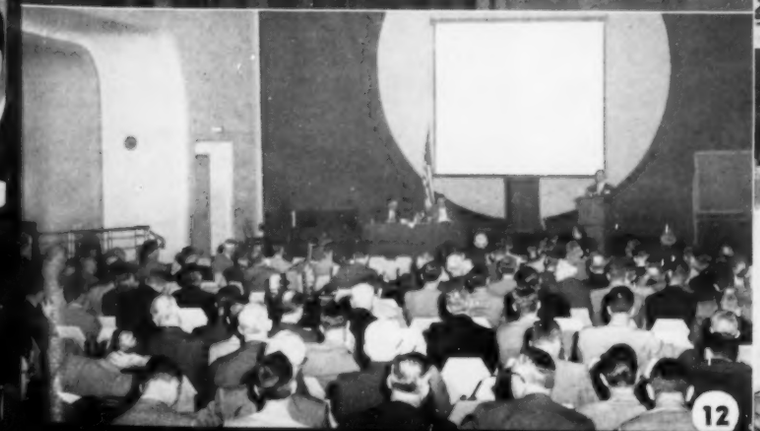
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equipment, installation and economics of Air Conditioning Existing Buildings

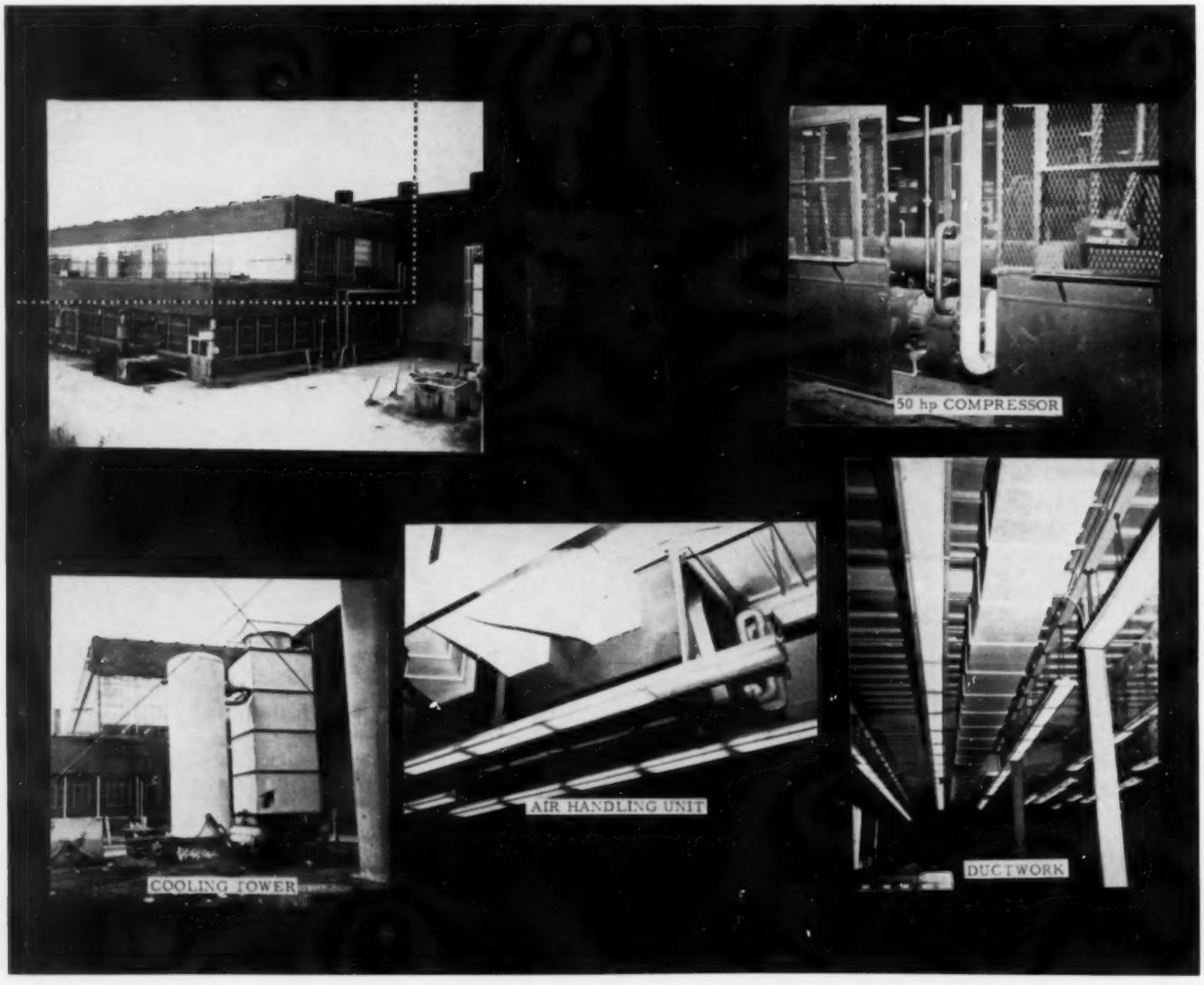
By
F. ROBERT DOUGHERTY
Engineering Dept.
Lukens Steel Co.
Coatesville, Pa.

▲THE coming of spring is a signal to dust off the air conditioning proposals. The increasing awareness of all concerned in the need for maximum seasonal comfort, has placed air conditioning high on the proposed capital expenditure list for many companies.

Most companies have office buildings of varying ages and constructions which have been or are now being considered for the installation of air conditioning. This paper will show the approach and solution to the problem at Lukens Steel Co.

The ballyhoo that has ushered air conditioning into our lives presents a confusing picture at first glance. It might be added that even on second and third glance the picture is still confusing. There are window units, central systems, package units, and all sorts of combinations of pipe and ductwork, various types of compressors, and a myriad of controls. Which is to be selected, and how does one go about separating the wheat from the chaff? In view of the many factors involved in the selection of a system—such as, initial cost, operating cost,

Figure 1 — A 50-ton central system was installed in the tabulating and payroll department.



. . . . a number of air conditioning systems were installed in various buildings at Lukens Steel . . . . relative cost per ton installed varied from $420 to $950 . . . . in general operating and maintenance costs are inversely proportional to installation costs . . . .

maintenance, useful life, and comfort requirements—it was decided to tabulate the major types of systems for comparison purposes.

After the compilation of comparative data, as shown on Table I, it was evident that a central system would be the most satisfactory solution. Which of the central systems were best suited to our needs? That was the next problem. After a time it became apparent, we were talking about central systems of 25-ton, 50-ton, 60-ton, 75-ton and 180-ton capacities to serve all of the major office facilities at Lukens. In total this involved 390 tons of air conditioning in five different locations.

After the building layout and construction were studied and comfort requirements were established, it was decided that ductwork was most advantageous in three of the buildings. A combination heating and cooling system consisting of under-the-window fan coil units could be used in the other two office buildings. Outline specifications were prepared so that each bidder would stay within defined boundaries. Design conditions and job scope was defined. The job of detail engineering was left to the successful bidder, subject to our approval.

The first system considered was for the office of the tabulating and payroll departments (Figure 1).

It was decided to use an air handling unit with ductwork because of the open and rectangular shape of the area to be conditioned. A 50-ton condensing unit was selected to operate by direct expansion of freon to one air handling unit since it was comparatively simple to

Figure 2 — In the main office, under the window fan-coil units supplied by a 75-ton compressor were used.

TABLE I
Air Conditioning Systems

Type	Description	Type no.	Useful life	Capacity range	Relative cost per ton installed	Maintenance cost per ton per year	Operating cost per ton per year	Advantages	Disadvantages
Window units	Compressor in each unit. Air cooled condenser. Units installed in windows.	I	5 years	½ to 2 tons	420.00	10.00	13.00	Initial cost low. Good flexibility of control.	Unsightly, relatively noisy, drafts makes window washing difficult, high operating and maintenance cost.
Package units A	Console type unit for each area with all components within each unit. Air distributed by grille on unit.	II	10 years	2 to 15 tons	485.00	6.50	10.40	Relatively pleasing appearance. Good area temperature control.	Variations of temperature in area. Takes up valuable floor space. Fairly high maintenance and operating cost. Relatively noisy.
Package units B	Console type unit for each area with all components within each unit. Air distributed by ductwork from each unit.	III	10 years	2 to 15 tons	503.00	6.50	10.40	Relatively pleasing appearance. Good area temperature control.	Valuable floor space used. Fairly high maintenance and operating cost. Relatively noisy.
Central system A	Centrally located compressor. Refrigerant (usually freon) piped directly from compressor to area air handling units with ductwork for air distribution.	IV	20 years	10 to 60 tons	600.00	5.50	6.25	Low maintenance and operating cost. Good area temperature control.	Air handling units relatively unsightly in areas.
Central system B	Centrally located compressor. Chilled water piped to area. Air handling units with ductwork for air distribution.	V	20 years	10 tons to unlimited	750.00	4.60	5.80	Low maintenance and operating cost. Good area temperature control.	Air handling units relatively unsightly in areas.
Central system C	Centrally located compressor. Chilled water piped to individual units in each office. Hot water can be used in winter.	VI	20 years	10 tons to unlimited	950.00	4.60	5.80	Maximum personal comfort control. Minimum floor space used. Can be used for heating. Pleasing appearance of units.	Highest installed cost.

locate the compressor on the first floor in the storeroom directly beneath the conditioned area. It was surprising to learn that 10 tons of refrigeration were needed to overcome the heat emission of the IBM machines alone in the tabulating department. This was a contributing fact to the subsequent approval of the appropriation.

Another item of interest is that we used an existing cooling tower that was and still is being used to cool the water for an air compressor installaton. Additional spray headers were installed and other minor alterations were made to increase the efficiency of the tower.

The cost of this 50-ton system complete and in operation was $382.00 per ton. The low price was due to simple duct runs, convenient equipment location and use of the existing cooling tower.

This was the first complete central air conditioning system at Lukens. The next four buildings, the main office building, highway office building, Strode Avenue office buildings and Lukenweld engineering building were bid and let at the same time.

In the main office, individual under-the-window fan coil units were selected (Figure 2). Sixty-five of them are supplied from a central 75-ton compressor and chiller located in a basement machine room. Each room unit is equipped with an individual thermostat and outside air control, summer and winter switch, and fan-speed control switch. They operate by 45 F chilled water in the summer and 130 F hot water in the winter. Air is distributed to the room by a fan in the unit through 4-way deflection grilles.

This type of system was selected because of the many private offices, the reinforced concrete floor construction (many places 26 in. thick), the flexibility of individual controls and for appearance. Of particular interest in this building is the method used to overcome the high latent heat load from occupants in the basement cafeteria. Individual under-the-window fan coil units were installed to handle the sensible heat load,

while a separate duct system from an air handling unit using 100 per cent outside air was installed to handle the cooling for maximum occupancy requirements. In this case a combination of central systems was used to suit a particular condition. The cost of this 75-ton system complete and in operation was $868.00 per ton.

The highway office was equipped in the same manner as the main office with 29 under-the-window fan coil units supplied by a 25-ton compressor and chiller installation in an adjacent carriage shed. The cost installed and in operation was $1,026.00 per ton. Note that the unit price per ton goes up as the size of the system goes down.

The Strode Avenue offices consist of a series of interconnected buildings (Figure 3). The main building is a three-story structure, formerly an old silk mill. The inter-connecting buildings are one-story structures.

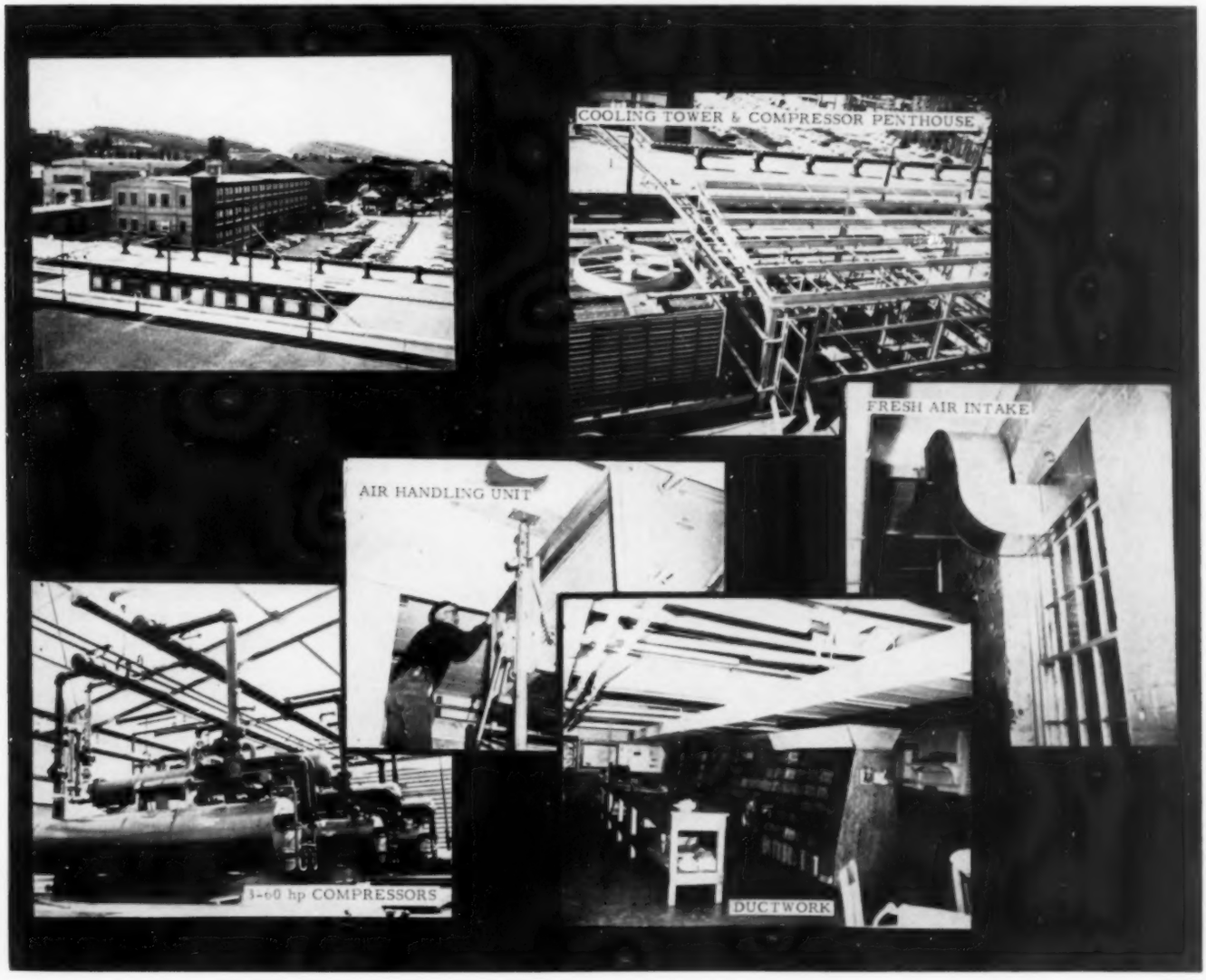
A stream flows nearby. So that there would be no possible danger from higher water, should the stream ever spill over its banks, compressors were located on the roof of the adjacent centralized maintenance building.

The 5-in. chilled water lines span a roadway to the Strode Avenue office buildings and distribute the water to 14 air handling units located in all areas of this building group. Ductwork carries the cold air from the air handling units for distribution within the areas. The ductwork system was selected because of the open areas within the buildings, high ceilings and narrow shape of most areas. Each air handling unit and duct system services from 5000 to 10,000 sq ft of floor area.

Of particular interest in this installation are the three 60-ton reciprocating compressors installed in parallel. Each compressor has four stages of unloading. The controls are such that each compressor unloads in capacity within itself, and the compressors unload in sequence, allowing unlimited flexibility in operating capacity and also subsequent power savings. Provision also has been made for varying the lead compressor and sequence so that each compressor will have its fair share of the load.

It is noteworthy that great stress was placed on maintenance and interchangeability of parts on all of the compressor installations. In spite of the various sized compressors from 25 to 75 hp, only one piston size and one bore and stroke is employed thus, minimizing spare parts inventory. Particular investigation also was

Figure 3 — A 180-ton central system was installed in the Strode Avenue office buildings.



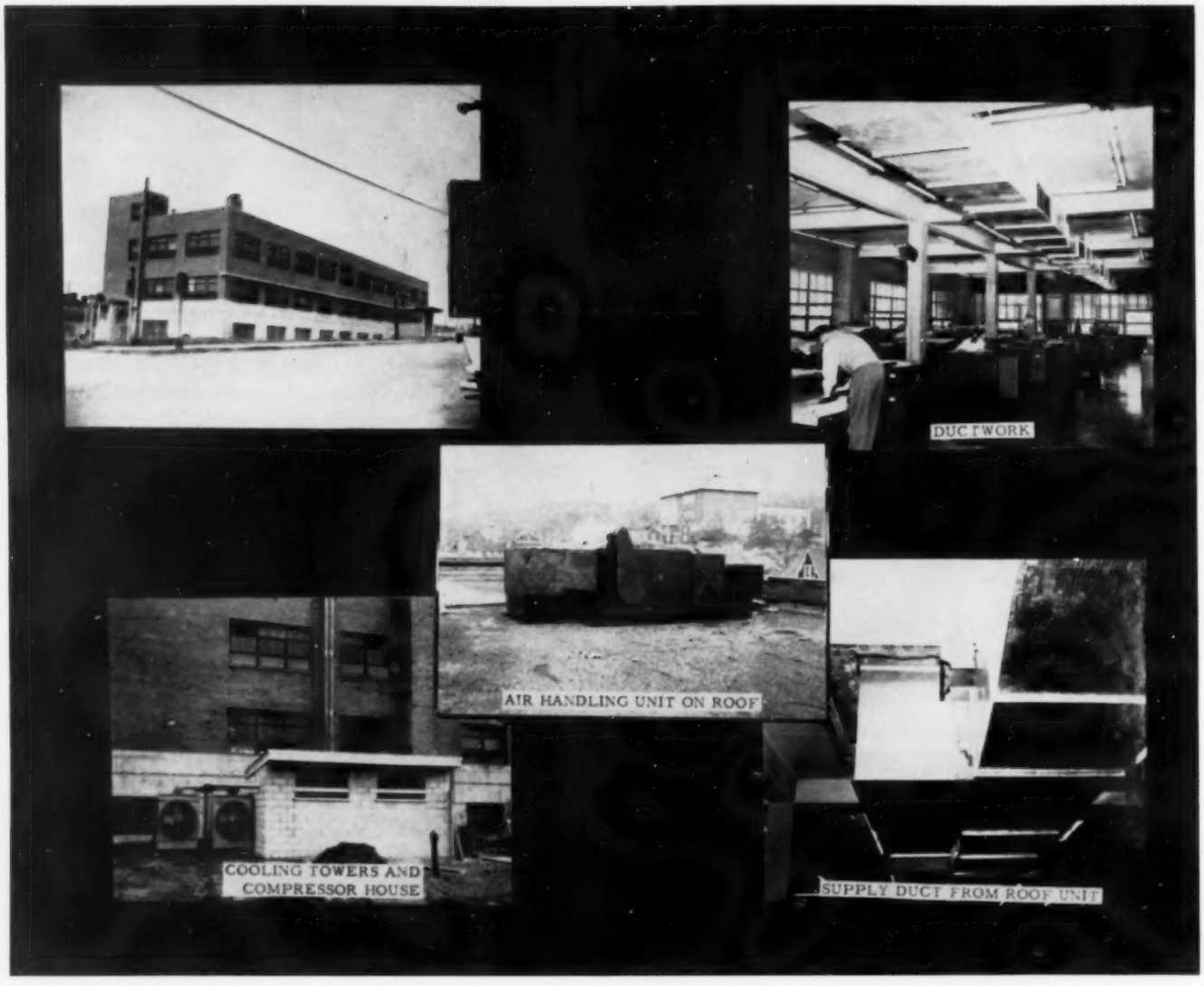


Figure 4 — The system in the Lukenweld engineering building is a 60-ton unit similar to that in the Strode Avenue building.

made in the preliminary stages as to the ease of teardown of the equipment for maintenance. At this stage, it was learned that there is a wide gap in compressor construction varying from poor to excellent, from a maintenance standpoint. The cost of this 180-ton system installed and operating was $654.00 per ton.

The system selected for the Lukenweld engineering building is similar to the Strode Avenue system, in that chilled water is circulated to three air handling units and ductwork is used for distribution of cold air (Figure 4). Of particular interest on this installation is the air handling unit installed on the roof, connecting to ductwork within the building. As a hindsight observation on the Strode Avenue installation, it is felt that we might have placed a few of these air handling units in roof locations. Possibly some savings in the installation would have been realized and there would have been a few less problems in hanging the units within the areas. The cost of this 60-ton system installed and operating was $629.00 per ton.

SUMMARY

A total of 390 tons of air conditioning were installed in five different locations. Total expenditure was $283,000.00 or an average cost of $725.00 per ton. The total expenditure figure includes power lines, foundations, compressor buildings and all items necessary for the job completion.

All of the equipment selected was carefully analyzed in the preliminary stages. Whenever practical, the items of various manufacturers were obtained and compared. Our inventory of components was such at one period that our offices were compared to Macy's basement.

Prior to the selection of the equipment, field trips were arranged, and many locations visited. The data compiled from observation and contact with owners were helpful in the selection of equipment.

All contractors bidding on the job were investigated as to background, experience, personnel and shop facilities as well as prior similar installations. Contractor integrity was a necessary pre-requisite in lieu of detail job specifications. In spite of the lack of detail drawings, total contractor extras amounted to less than 2 per cent of the contract price.

We hope that this venture at Lukens will be a guide in some small degree to the approach and solution of other problems in this field.

AUTOMATIC GAGE CONTROL for cold reduction mills

. . . . a major analytical analysis of rolling mill operation has been necessary to set up the principles which must govern automatic control design . . . . the following paper summarizes these results in simple language and puts in theorem form many of the principles known to most operators through experience . . . .

By
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and
H. S. MAXWELL
Steel Mill Engineering
Systems Application Engineering Section
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Schenectady, N. Y.

▲ SINCE the development and successful application of noncontact radiation-type thickness gages over the last few years, the development of automatic gage control systems has followed closely. For the first time it is possible to control directly the production of on-gage strip. As a result, there has been considerable interest on the part of persons responsible for steel production in the various plants throughout the country. Two papers[1],[2]* have been presented this year which describe the gage control system developed for five-stand tandem cold reduction mills. This paper discusses the application of automatic gage control systems to other types of mills as well.

When the automatic gage control development was begun, it was decided that a major analytical investigation should be undertaken by the authors' company. The object was to find the underlying physical principles of the behavior of all types of cold reduction mills and to describe them mathematically so control systems could be devised, studied, and optimized. A major part of this theoretical investigation has already been reported.[2] This and practically all of the other studies of rolling mill behavior have been presented in the literature in a mathematical form. This paper translates the mathematics into words which describe the behavior of various types of cold reduction mills to explain how and why automatic gage control systems differ for various types of mills.

PHYSICS OF THE ROLLING PROCESS

A brief explanation of the physics of the rolling process is in order. Strip is made to flow plastically by squeezing it between the work rolls, as shown in Figure 1. If in addition, tension is applied to the strip as it enters or leaves the roll gap, the roll pressure required will lessen since plastic flow theory says that the vertical compressive stress plus the longitudinal tensile stress must equal the yield stress at every point in the roll gap.[3] The rolls and the mill housing act like a large spring, and tests show that the combination obeys Hooke's law in the working range;[4] that is, there is a linear relationship between change in work roll force and change in roll opening. Therefore, when tension is applied at either the entry or exit side of the roll gap, the roll pressure lessens, and the work rolls move closer together until a new point of equilibrium is reached where compressive stress plus tensile stress once more equals the yield stress. The delivered thickness of the strip thus decreases. This suggests that outgoing thickness can be decreased by increasing incoming or outgoing tensions or by increasing roll pressure. This explains what rollers know by experience.

If it is assumed that cross-sections of strip remain plane when passing through the roll gap, it follows that when reduction is being taken, there is a neutral point on the roll arc of contact where the roll pe-

* Numbers refer to Bibliography at end of paper.

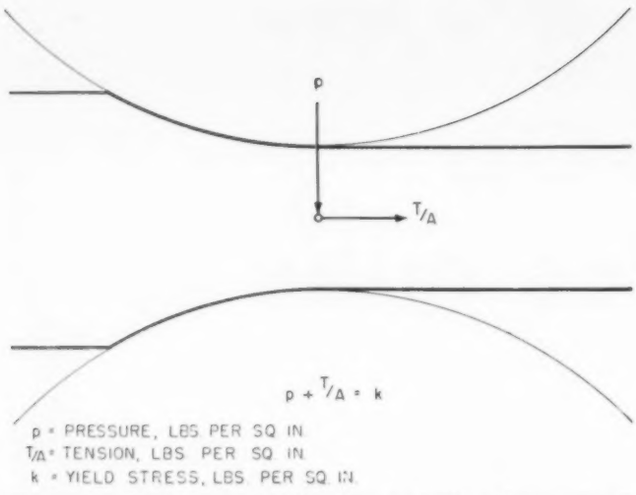


Figure 1 — Sketch of roll bite shows relations between roll pressure, tension and yield stress.

ripheral velocity equals the strip velocity. This is the point labeled "n" in Figure 2. On the entry side of this point, the rolls are moving faster than the strip; on the delivery side of this point the strip is moving faster than the rolls. An increase of incoming tension causes the neutral point to move toward the exit; an increase of outgoing tension causes the point to move toward the entry, thereby increasing extrusion.

That these observations are correct can be shown by a physical picture. Suppose the incoming tension is increased gradually. The work rolls will encounter an increasingly difficult job of pulling the strip through and will eventually begin to slip. Under this condition, the rolls will be moving faster than the strip throughout the entire roll gap. This is, of course, the limiting case of the phenomenon described above.

SINGLE-STAND MILL WITH BOTH WIND AND UNWIND REELS

Figure 3 (top) shows a single stand mill with wind and unwind reels. The mill motor is usually controlled by a voltage regulator with adjustable IR drop compensation. Both the unwind and the wind reels are controlled by two regulators. One regulator, working through the motor field, matches reel motor counter-emf to mill motor speed as measured by a tachometer; the second regulator regulates reel motor current by controlling the terminal voltage of the reel generator. Since the reel motor armature current is being regulated, the total tension (in pounds) will be held constant in the steady state. During transient operation, there will be accelerating currents in addition so that, even if the current regulator could hold the current absolutely constant, there will be tension variations during the transient condition.

Referring again to Figure 2, suppose that the single stand mill is rolling a product under constant conditions of thickness and tension but that the delivered gage is thicker than desired. If the screwdowns are lowered, the roll force increases. Assume, for the moment, that the entry and exit tension remain the same and the delivered gage is reduced. Calculation indicates that the neutral point shifts very little under this condition. On the basis that the neutral point stays in the same position relative to the entry and exit of the roll gap and that the mill motor speed does not change, the velocity of the entering strip will decrease and the velocity of the exiting strip will increase. This can be visualized in the following manner. Under the new rolling condition, a greater reduction is being taken between entry and neutral point so, for constant speed at the neutral point, the entry speed will decrease. In addition, a greater reduction is being taken between neutral point and exit so the exit velocity will increase. Since the winding reels cannot change speed instantaneously, both the incoming and outgoing tensions will decrease. Since a decrease in tension tends to produce an increase in delivered gage, the net result is that from the time the screwdowns are lowered until the reel regulators act to restore tension, the two above effects almost cancel each other and the thickness changes only slightly. Therefore, an automatic gage control utilizing correction by change of screwdowns can be no faster than the speed at which tension is corrected.

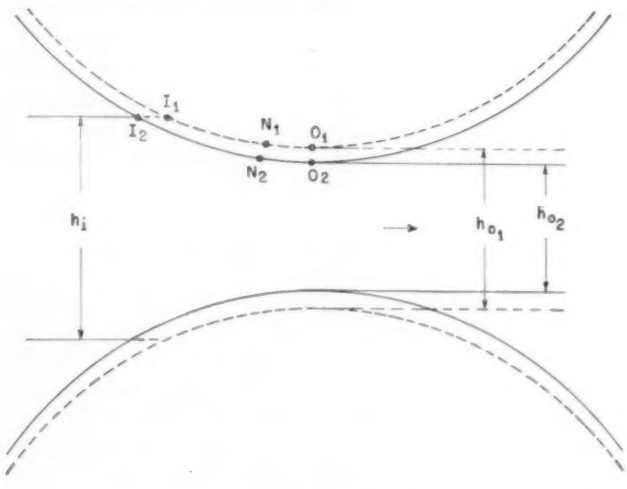
There are two considerations which have been shown by calculation to have a bearing upon the choice of correction methods.

As an approximation, it can be said that, for the schedules normally rolled in a cold reduction mill, the ratio between per cent change in roll force and per cent change in output thickness does not change from pass to pass. It has been found that the total roll force does not vary appreciably from pass to pass. Since the mill acts like a huge spring, there is a fixed relation between mils change in screw position and pounds change of roll force. It follows that the ratio between mils change of screws and per cent change in output gage does not change much from pass to pass.

It is also logical that an increase in psi of input or output tension will reduce the roll pressure required for reduction by a like number of psi regardless of the pass. It follows then that there is a fixed ratio between change in psi of tension and per cent change in output gage from pass to pass.

On the early passes, the strip has a large cross-sectional area and the total tension required to effect a given per cent change in thickness is much higher than on later passes where the cross-sectional area is small.

Figure 2 — Sketch shows relations for two reductions in one stand of a steel rolling mill.

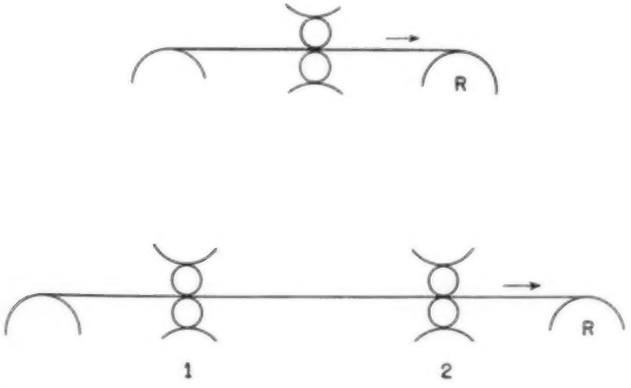


The reel motors are of limited torque. As a consequence, from a practical standpoint, thickness must be controlled on early passes with screws. The logical choice then would appear to be to use screws for all passes, but there is a limitation that is based on a phenomenon which has not been mentioned before in this paper. As the ratio of roll diameter to strip thickness gets larger, the rolls begin to flatten to a rather large extent over their arc of contact with the strip. Finally, a point is reached where an increase in roll force with constant incoming and outgoing tension produces a thicker strip rather than a thinner one. What happens is that the flattened rolls cover a larger area of strip in the arc of contact than before and, although the total roll force has increased, the pressure (force per unit area) actually decreases. When this condition is approached, effective control must be by tension. Our studies show that this transition occurs on large four-high mills such as those 40 in. wide or wider rolling down to or below tinplate thicknesses.

AUTOMATIC GAGE CONTROL FOR A SENDZIMIR MILL

There are three factors in the design of a sendzimir mill which reduce the roll flattening effect greatly. The first is that very small diameter work rolls are used. Secondly, the work rolls are made of tungsten carbide which has a modulus of elasticity about twice that of steel. Thirdly, the work and backup rolls are run in an oil bath which minimizes the coefficient of friction between the work rolls and the strip and thus minimizes the roll force required for a given reduction.[5] The reduction in force required reduces the roll flattening too. Therefore, screwdown control can be used successfully down to very thin gages. With the very small rolls, comes a very short contact arc and the frictional forces which prevent slippage between the strip and the work rolls for sizable excursions of tensions in an ordinary single stand mill are not sufficient to prevent slippage in the Sendzimir mill. The control of strip thickness by tension in such a mill appears to be difficult from a practical application standpoint. The automatic gage control will detect the thickness deviations as measured by an x-ray gage and control roll force. The hydraulic roll positioning mechanism of sendzimir mills lends itself to the use of a continuous action control which adjusts roll force in proportion to thickness error. We prefer the use of this type of control to a sampling type control wherever possible.

Figure 3 — Sketch of rolls and reels in one-stand and two-stand rolling mills.



AUTOMATIC GAGE CONTROL FOR SINGLE-STAND ALUMINUM FOIL MILL

In view of what was said before about screwdowns of mills using large work rolls being ineffectual in regulating strip thickness when thin gages are being rolled, it is clear that control of gage in a foil mill cannot be by screwdowns.

Up to now, no mention has been made of the effect on gage of variations in the speed at which it is rolled. When strip is reduced in a cold mill it is almost invariably lubricated with some type of oil or mixture of oil and water. When the speed is raised on the mill while the unwind and wind reel controls act to hold constant tension, the delivered gage decreases. The consensus of research studies seems to be that the lubricant is carried into the roll gap more effectively at higher speed. This decreases the coefficient of friction, less roll pressure is required as a consequence, and the spring of the mill forces the work rolls together until a new equilibrium point is reached.

In the aluminum foil industry, experience has proved that on the passes where the strip is thin, the speed of the mill may be regulated manually to hold delivered gage more nearly constant. On the early passes, incoming tension is effective in the control of gage and is usually used. On the passes where the strip is thin, unless tension is kept to a very low value, edge cracks in the strip are likely to develop into breaks in the foil. It was decided, therefore, that for the pilot gage control equipment, which has been in service for some time, gage would be controlled by incoming tension on the early passes and by mill speed on the later passes. A disadvantage of the use of mill speed alone is that about a 15 per cent range of speed is required to effect control of gage. As a consequence, average speed must be lower than rated mill speed. We are working toward a combination of speed and tension as control variables.

TWO-STAND TANDEM MILL WITH WINDING REEL

Figure 3 (bottom) shows a two-stand tandem mill with winding reel. Normally, the uncoiler is not powered and entry tension can be assumed zero at all times. When strip is passed through two reducing stands in succession, with tension in the strip between the stands, the behavior of the mill is considerably different from the single stand mill.

Consider first a rolling condition similar to that described for the single-stand mill; that is, suppose that the mill is rolling a product that is thicker than desired. Suppose the screws on the second stand are lowered. There will be a period before the wind reel regulator acts to restore tension when the two stand mill will behave much like the single stand mill with unwind and wind reels. That is, the tension in the strip entering and leaving the second stand will decrease when the roll pressure is increased by the movement of the screws and there will be very little change in delivered gage. When the wind reel regulator acts to restore

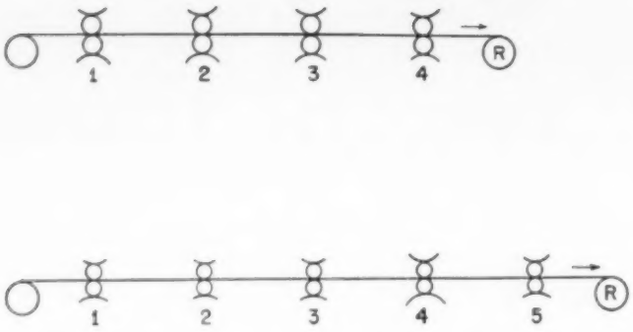


Figure 4 — Sketch shows rolling in four-stand and five-stand tandem cold reduction mills.

tension, the delivered gage will become somewhat thinner than it was originally.

This condition, too, is only temporary however since the decreased tension between stands one and two will have caused the strip delivered from stand one to be thicker. This will propagate to stand two. When it enters stand two, the stand will have to take a greater reduction than before and the work rolls will spring apart. Thus, when the screws are lowered and the transients have all died out, there will have been practically no change in delivered gage. In a stiff mill, a mill having a ratio of deflection to force that is very small, the gage will be somewhat thinner than before. In a relatively springy mill the delivered gage will actually be somewhat thicker than before.

On any multistand mill without interstand tension regulators the screws of the delivery stand have very little influence on delivered gage. Their position does, however, have a big influence on the nominal tension between the delivery stand and the preceding one. It may be said that the position of the screws on the delivery stand determines whether reduction in the last stand is largely by roll pressure or by combination with tension.

Theoretically, it is possible to bring the delivered strip back on gage by increasing the current reference setting of the winding reel. Normally, however, the horsepower of the winding reel is not sufficient to obtain sufficient range of correction. In addition, good coiling action may be impaired if the coiling tension is varied over a wide range.

The tension between stand one and stand two can be increased by slowing down the stand one drive motor. This will produce very little change in coiling tension so the speed of response of the winding reel regulator will not influence the speed of correction. The increased tension will produce a thinner strip out of stand two and also out of stand one although it will be a smaller percentage change. In time it will propagate to stand two and a secondary change in delivered thickness will result.

An automatic gage control can thus be designed which will measure the thickness of the strip delivered from stand two and control the speed of the stand one drive motor and thus vary interstand tension to bring the delivered strip back on gage. If the thickness variations entering the first stand are not large, such a system should do a satisfactory job. If the thickness variations are large, however, the range of tension required to effect control of gage may be larger than can be tolerated for practical reasons.

A second gage could be added to measure the thickness delivered from stand one and the screws of stand one could be controlled to regulate the stand one delivered thickness. The speed control would then be required to operate over a much smaller range. Since the variation of speed of the stand one drive motor has an influence on the thickness delivered from stand one, there will be some interaction of the two regulators with the result that a system with two regulators cannot be made as fast as a system with just the one regulator. If the total reduction to be taken in the strip necessitates multiple passes, it would be necessary to control the stand one screws on the first pass only. On later passes a single regulator controlling speed would be sufficient.

A second system utilizing two thickness regulators is possible if the tension between stands one and two is regulated by controlling the speed of the stand one motor. It is then possible to use identical thickness regulators controlling the screwdowns on each stand. The two gage regulators will then operate independently up to the point where their speed approaches that of the tension regulator. Thus the speed of response of this system is limited to something slower than the speed of response of the tension regulator.

AUTOMATIC GAGE CONTROL FOR TWO-STAND TANDEM MILL FOR ALUMINUM STRIP

Interstand tension regulators are quite common in the aluminum industry and the thickness of aluminum strip is controlled manually by moving the screwdowns. Since there seems to be no particular theoretical advantage of using one of the above described systems rather than the other, it seemed wiser to choose the system which makes the least departure from present practice in the industry in designing the first automatic gage control system for this application. Therefore, an interstand tension regulator and two screwdown type automatic gage controls make up the system. When sufficient operating experience has been obtained with this system, a simpler one may evolve.

FIVE-STAND TANDEM COLD REDUCTION MILL

All of the high production cold reduction mills in this country which produce steel for tinplate are five-stand tandem mills (Figure 4 bottom). The large potential dollar savings which would result from increased on-gage output made possible by continuous regulation of thickness could be easily predicted. Thus, this was a logical type of mill on which to begin gage control system development.

Over the years the operating personnel of this type of mill have developed techniques of manually controlling thickness of the delivered product. It is the almost universal practice to control gage as delivered from the fifth stand by varying the speed of the fifth stand drive motor. Many operators felt that if the thickness of the strip delivered from stand one were held more nearly constant, the control range necessary in stand five would be greatly diminished. A promising solution to the problem of building a continuous auto-

matic gage control system was to regulate the thickness delivered from the first stand by controlling the screws of the first stand and to regulate the thickness delivered from the last stand by controlling the speed of the last stand. There was no guarantee, however, that such a system was the best choice possible or that it would work on a continuous basis. Therefore, a major analytical investigation was undertaken.

Since the steel strip which enters a tandem cold reduction mill has previously been rolled at a temperature of 1700 F or higher, no variations in yield stress can be expected except those slight ones resulting from variations in alloying elements throughout the length of the strip. The only significant variations in the entering strip are those in thickness. When the entry thickness increases, more force is required from the work rolls to hold the same delivery thickness. The screws of the first stand must be lowered to supply this force. It is reasonable to expect that such corrective action, whether manual or automatic, will produce little in the way of secondary effects. Theoretical studies have verified that an increase in incoming thickness corrected in this manner produces but a slight decrease in interstand tensions. These reduced tensions cause a slight "springing" of the remaining stands and a slightly thicker product issues from the mill. If the regulation of the thickness delivered from the first stand were perfect, little or no regulation would be required at the delivery end of the mill except for one additional factor. The portion of the strip which was heavier at start will be reduced more and thus will be work hardened more than the rest of the strip, although it entered the second stand on gage, the second stand rolls will spring apart slightly and off-gage material will issue from stand two. A similar phenomenon will occur in each of the succeeding stands. In other words, the thickness deviation will "grow back in." This trend is significant and requires that a correction be made later in the rolling process.

Control of delivered thickness solely by positioning the screwdowns of the last stand is not effective for the same reasons as were pointed out in the discussion of two-stand tandem mills. Again coiling tension is impractical to use. The only control variable left which affects delivered gage directly is the tension between the fourth and fifth stands.

AUTOMATIC GAGE CONTROL FOR FIVE-STAND TANDEM COLD REDUCTION MILL

Two completely separate regulators were designed for the first completely integrated automatic gage control system. A "coarse" sampling-type regulator controls the screwdowns of the first stand; a "vernier" continuously-acting regulator controls the speed of the stand five motor. This automatic gage control system is discussed fully in reference 1.

Since the speed of the strip as it leaves the first stand is slow relative to the delivery speed of the mill, a substantial transport time exists between the roll bite where correction is made, and the point where an x-ray gage measures the strip thickness, particularly during the low-speed threading operation. A sampling system which moves the screws an amount proportional to the thickness deviation and then waits for the corrected strip to reach the gage was the logical choice. Such a system can remove major gage variations and is thus called a "coarse" control.

At the delivery end of the mill, the transport time between the roll bite and the x-ray gage is not the major time delay in the system so a continuous control is practical as well as desirable. The x-ray gage measures the thickness deviation of the delivered strip and continuously controls the speed of the stand five motor, thereby controlling the input tension. As was pointed out earlier, however, practically no corrective action takes place until the winding reel control acts to restore coiling tension. Therefore, interaction between the "vernier" control and the winding reel regulators is inevitable. Practically speaking, this means that the speed of response of the automatic gage control can be no greater than the speed at which coiling tension is restored by the winding reel regulator.

As in the case of the two-stand tandem mill, if the speed of the stand five motor is increased to correct for heavy strip delivered from stand five, the increased tension between stands four and five will produce lighter strip out of stand four than existed previously. In time it will propagate to stand five and require a decrease in stand five speed. The result is that the stand five motor appears to be overshooting. The interaction of the gage control and the reel regulator and this transport phenomenon require that the controls of the mill be integrated. The use of an analog computer was found very useful in studying the proper means of integrating the controls.

Theoretically, it would be possible to slow down the first four stands together as a unit rather than to speed up the fifth stand to produce an increase in tension between stands four and five. The winding reel control would have to make very little adjustment and practically speaking, it would not interact with the gage control. However, it does not seem sound engineering to tie four stands together when integrating the controls of the fifth stand and the reel is the alternative.

There are numerous alternate automatic gage controls which can be conceived. Of particular attractiveness are those which measure and regulate thickness at one point only. An obvious alternative is to use the "coarse" control of stand one and eliminate the stand five "vernier" control entirely. The cost will be cut roughly in half. Our experience is that the "coarse" control alone is usually sufficient to hold gage variation within present commercial tolerances, and that the "coarse-venier" system holds the delivered gage variation to one-half that attainable with the "coarse" control alone. There is reason to believe, however, that today's premium strip will be tomorrow's standard.

There is a second alternative lower cost system applicable to tandem mills with adjustable voltage drive for each stand. It was pointed out before that if an effort is made to hold delivered gage by controlling the speed of stand five without help from the stand one screwdowns, the control range in stand five may be excessive. As an alternate to the use of a stand one regulator controlling screwdowns, the speeds of stands four and five may be controlled simultaneously with the effect that the tension between stands three and four as well as the tension between four and five will be varied. If the two stand speeds are varied the same

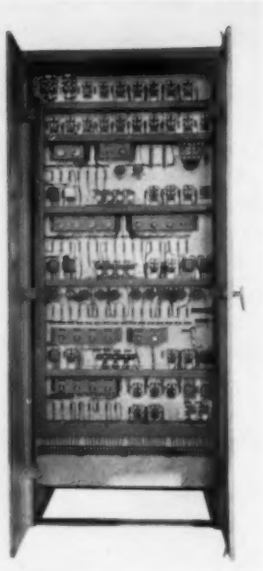


Figure 5 — Panel mounted devices are arranged for front connection. Shown here is automatic gage control for five - stand tandem mill.

Figure 6 — Back view of cabinet which houses automatic gage control for five - stand tandem mill.

percentage, there will be practically no variation in tension between stands four and five. For this case the speed change will first produce a thickness change in stand four, which will propagate to stand five, produce a thickness change in stand five, which then propagates to the x-ray gage.

This system then has the disadvantage that the total transport time is about five times the transport time from the stand five roll gap to the x-ray gage. If the speeds of stands four and five are varied together but by different percentages, the effective transport time will be lessened. However, this alternate cannot be made to correct thickness errors as fast as the "coarse-vernier" system.

We are presently building a "single gage type" equipment for a four-stand tandem mill. Provision is made to control the speed of any one, two, or three stands as a function of delivered thickness deviation. On certain schedules it will be possible to try the above alternate and evaluate it. It will then be possible to determine its proper field of application.

AUTOMATIC GAGE CONTROL FOR FOUR-STAND TANDEM MILL WITH WINDING REEL

With the exception of the application just mentioned, all of the gage control systems which we are building for four-stand mills will be "coarse-vernier" systems. Our studies have shown that the four-stand mill is like the five-stand mill in that variations at the delivery end of the mill have little influence on the product issuing from the first stand. Therefore, a sampling-type "coarse" control, identical to that employed in the gage control system for a five-stand mill, is being provided for the first stand.

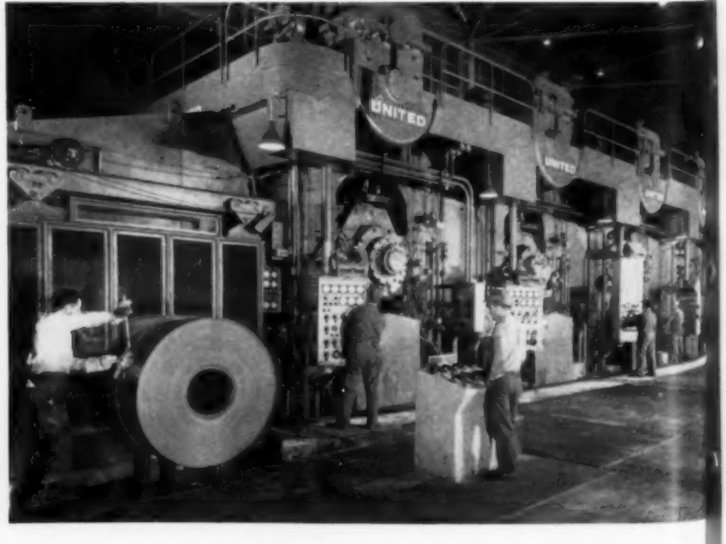
Whereas reduction in the last stand of five stand mills is usually at least 25 per cent, reduction in the last stand of four stand mills may be as little as 5 per cent on some schedules. With this relatively light reduction, the roll separating force will be relatively low. Therefore, the frictional forces which prevent slippage between the strip and the work rolls for variations in tension between stands three and four will be relatively low. If the "vernier" gage control regulates thickness by controlling the speed of the stand four motor, the tension variations required may be sufficient to produce slippage. Therefore, provision will be made to control the speeds of stands three and four simultaneously if necessary. Otherwise, the automatic gage control system for the four-stand mill will be identical to that which has proved successful on five-stand mills.

FIELD EXPERIENCE WITH AUTOMATIC GAGE CONTROL SYSTEMS

Five-stand mill installations—Use of coarse and vernier thickness regulators has become routine on the first five-stand mill so equipped. During more than a year of operation, mill maintenance men have provided nearly all maintenance. This is considered important because it was necessary for them to become familiar with new components and circuits including transistors, small magnetic amplifiers and telephone relays.

We believe on-the-spot instruction of both operators and maintenance men was an important factor in obtaining nearly full time service.

Figure 7 — New five-stand cold mill at Weirton Steel is equipped with both coarse and vernier thickness regulators.



All panel-mounted devices are arranged for front connection and mounted on steel panels in cabinets as shown in Figure 5. All devices are visible, accessible and easily replaceable. This new construction has established a pattern for subsequent equipment. As volume develops, we expect to use modular construction to obtain the advantages of interchangeable sub-assemblies.

The automatic screw return equipment shown in Figure 6 has proved valuable in reducing the amount of off-gage rolled during acceleration since greater reduction in the first stand at threading speed partially offsets the decrease in reductions in other stands.

During the past four months, operators of the second five-stand mill to be equipped with both coarse and vernier thickness regulators, shown in Figure 7, have increased their familiarity and extent of use of the automatic equipment until it is essentially in full time operation.

Operators are understandably cautious in accepting new developments and require time for first hand experience with the new vs the old.

Acceptance of full time use of automatic gage control on this second installation was preceded by transfer from the use of contact gaging plus x-ray gage monitoring to full time x-ray gaging. This reportedly resulted in a substantial increase in the percentage of total tonnage rolled on-gage. Automatic control can result in further increase, but of particular interest to the tinplate consumer, closer tolerances are held.

Adjustable voltage screwdown control has permitted stand one screwdowns to operate more frequently than would be practical using magnetic control. This ability to operate more frequently has permitted reducing the tolerance on thickness of strip delivered from stand one approximately 25 per cent as compared with tolerance thus far obtainable with magnetic control. Figure 8 shows stand one x-ray thickness gage and operator's cabinets including controls for coarse regulator.

Figure 9 — Motor drive room of five-stand tandem mill shows No. 1 stand motor in background. Control panels for regulators are located in motor room on right.

X-ray gage and automatic gage control panels for the coarse regulator and vernier regulators are very conveniently located for servicing, being within the motor room but close to the associated x-ray gages on the mill, stand one panels are visible in background, stand five panels in foreground of Figure 9. Figure 10 shows a closeup of stand five x-ray thickness gage control panel.

The charts of Figure 11 show that present control does not prevent an increase in thickness as the mill is slowed for a weld. However, close tolerance is held longer before the weld and returns more quickly following the

Figure 8 — X-ray thickness gage and operating control for coarse regulator of five-stand tandem mill.

Figure 10 — Closeup of stand 5 x-ray thickness gage control panel.

weld than with manual control. Stand one screws lower in an effort to hold gage as speed decreases or as a thick tail preceding the weld passes through the x-ray gage. Screws raise following the weld in an effort to avoid rolling too thin strip as speed increases or as a thin head following the weld passes through the x-ray gage. The decrease in sampling frequency of the coarse regulator with decreasing mill speed is shown in the lower trace. Changes in winding reel current as shown in the upper trace are purposely introduced as a function of thickness deviation. Resulting torques assist the reel in changing speed to follow changes in stand five speed.

Foil mill installation—Kaiser Aluminum and Chemical Corp., Permanente, Calif. made possible the development of an x-ray gage for measuring thin aluminum strip and foil and an automatic gage control system using this x-ray gage.

This 3000-fpm non-reversing 4-high mill, shown in Figure 12, equipped with regulator operating primarily through control of mill speed, holds closer tolerances on each successive pass than obtained with manual control.

Aluminum strip does not contain thickness variations comparable to those in steel strip produced when cold spots pass through the hot strip finishing mill. Accordingly a relatively simple low gain regulator appears adequate.

USE OF COMPUTERS IN THE STUDY OF ROLLING

The equations[5] which describe mathematically the physics of reduction between rolls are nonlinear. Their solution is rather complicated from a numerical standpoint because of the number of calculations required. The nature of the nonlinearities make it impossible to use them directly on an analog computer to study the transient behavior of the various mills. Fortunately, the transient conditions which must be studied are those of rather small changes from the nominal (or ideal) rolling conditions for a particular schedule. A large scale digital computer has been programmed to find from the nonlinear equations the approximate equations which describe the small changes.

Figure 11 — Oscillograph shows that automatic control will not completely control or correct for weld in strip.

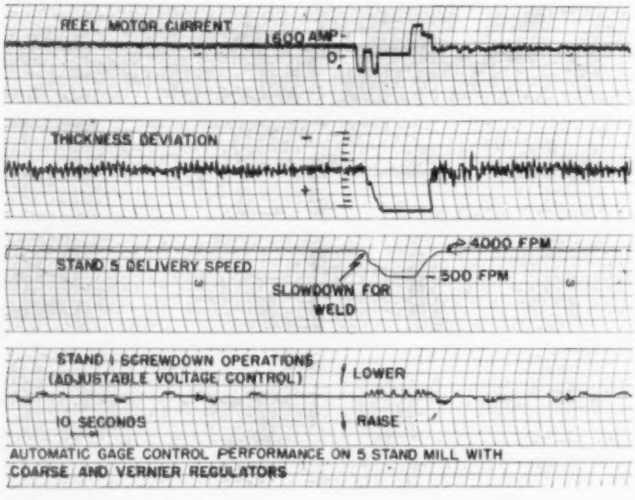


Figure 12 — Delivery end on four-high tandem foil mill shows x-ray gage holds closer tolerances than possible with manual control.

These equations can then set up on an electronic analog computer (2) together with the transient equations of the drive motors and the regulating systems. It then becomes possible to study the interaction of the various regulators and devise stabilizing and co-ordinating methods prior to installation of the equipment. From the analog and digital computer studies it has been possible to build up the physical picture of the operation of the various mills; this physical picture has been presented here. From this basic understanding, it is possible to select a workable system for new gage control application problems as they arise. On some systems further computer studies are unnecessary. Of course, it is not possible to anticipate every practical problem which may arise when equipment is placed in service. The analytical knowhow and the computing equipment is available to help find solutions to these problems as soon as they arise.

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3. "*Plasticity*" (*book*), by A. Nadai, McGraw-Hill Book Co., New York, 1943, p 78.
4. "*Principles of Continuous Gage Control in Sheet and Strip Rolling*," by W. C. F. Hessenberg and R. B. Sims, Proc. Institution of Mechanical Engineering, vol. 166, 1952, pp 75–81.
5. "*The Calculation of Roll Force in Cold Strip Rolling with Tensions*," by D. R. Bland and Hugh Ford, Proc. Institution of Mechanical Engineering, vol. 159, 1948, pp 144–153.

DISCUSSION

PRESENTED BY

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M. D. Stone: I would like to applaud the work as being a real approach to a very difficult subject. I should like to mention as well that work is being done in England along similar lines. I think the British Iron and Steel Research Association should also be given credit for initiating some of this type of work, and they have come up with an original type of automatic control that should be mentioned along with the types that were discussed today, because they potentially have introduced something that I think none in this country as yet have.

Automatic gage control is an extremely complex problem, and you cannot expect to solve a complex problem simply.

My impression from glancing over the paper is that in one or two places the author has made some simplifications, or over-simplifications. In one place he mentions that substantially the same pressures are used in all passes of a reversing cold mill, and that substantially the same change in gage with change in pressure also holds. Actually, I think he contradicted himself somewhat, because later on in the paper he does mention the true fact that in the fifth stand of a 5-stand tandem tinplate mill, for instance, where the material gets very thin, you actually get practically no change in gage with a very substantial change in pressure. It is generally true, that in the last stand you do have a greater change in pressure for a change in thickness than you do in the earlier stands. Some years ago we actually ran into a case as Mr. Phillips mentioned where the effect was reversed, i.e., that you can bring the screws down and the thickness actually increases. I have never personally seen but this one case. The operator was totally amazed and for the reasons recited.

Now as the material gets thinner, you have very much less chance to control gage by pressure, and conversely, a small change in thickness involves a fairly large change in pressure. And this is the essential point that I want to call your attention to that they are working on in England, and I presume it is going to attract some attention over here. That is, in addition to using the change in thickness of the strip as measured by an x-ray gage, (which necessarily involves a time delay, as Mr. Phillips mentioned, since the distance between the gage and the mill results in a variable transport time, depending on whether the operating speed is constant or the mill is coming up to speed, and therefore cannot be avoided) they have introduced a signal response due to changing pressure with changing gage, as it occurs in the mill bite. That is, as a change in thickness takes place, immediately and with no transport time whatsoever, a change in pressure takes place, and they are monitoring their control system with that change in pressure as well as the subsequent and attendant change in thickness.

R. A. Phillips: Dr. Stone mentioned what he said was over-simplification. We would like to go over that one point once more and amplify it.

We made the statement that it did not matter much which pass you were taking in a schedule on the roughing mill, as far as the ratio between change in roll force and per cent change in delivered thickness. That statement is still substantially true for the usual rolling practice.

Then the question arises: Why do we see this phenomenon in a five-stand mill, where we know if we come down on the screws in the fifth stand we can get substantial tension changes between the fourth and fifth stand with practically no change in delivered thickness and in some particular cases we come down on the screws and actually get an increased thickness?

When you come down on the screws of the last stand, there is a proportionately greater reduction between the entry to the last stand and the neutral point. Therefore, the entry speed has decreased over what it was before, and as a consequence, if we assume the speed coming out of the fourth stand does not change, the net result is that although we increase the roll force, we no longer are getting help from the back tension. You see a combination of these two effects and the net result is that you have practically no net change in gage.

The British work is very interesting. We are not sure all readers are familiar with the measuring scheme to which Dr. Stone refers. Mr. Hessenberg and Mr. Sims, while with BISRA, organization in England, made use of the fact that the mill housing, screws, backup rolls, and work rolls act together like a huge spring. Therefore, if there is a change in separation of the work rolls, it will be accompanied by a change in total roll force. They have made use of this phenomena as an indirect means of measuring change in delivered thickness. There is a very real drift problem involved in such a device since the mechanical parts of the mill and the rolls change dimensions with temperature and with wear. The reference must be corrected from time to time by comparison to a monitor at least at the delivery stand. (The use of an x-ray gage as a monitor in a 5-stand tandem mill is becoming almost universal in this country.)

The problem of transport time is the only one of consequence. In a high speed 5-stand tandem mill, the delivery speed is of such magnitude that the transport time is between 0.05 and 0.10 seconds, so that is not an important factor. Therefore, we prefer to use a single method of measuring thickness which is more direct than the one mentioned by Dr. Stone.

The problem of gaging at the first stand is a little

different. There the transport time is significant. We find the sampling type of control system to be perfectly satisfactory and most practical to apply in many installations. If you have a sampling type system, instantaneous reading of simulated thickness does not seem to be too important. We think any satisfactory method of measuring thickness at the roll bite will find application on other types of mills, however.

L. F. Stringer: The complexity of the overall system demands the use of large scale computing equipment for its analysis.

There was one point I noticed on which some of the other members might wish to comment, and that is the speed dependency of the coefficient of friction between the mill roll and the strip. This phenomenon is important, especially in the cold rolling of aluminum foil. The authors' account of this dependency appears to be an over-simplication, and it would seem that additional information on this matter would be of considerable interest.

As Dr. Stone has mentioned, the use of roll force measurements in automatic gage control systems can lead to superior results, and it is anticipated that such measurements will be employed widely in automatic gage control systems.

R. A. Phillips: Regarding the question of lubrication, we merely reported what we thought was the consensus of research opinion.

N. S. Wells: This paper and more theoretical papers by the same authors, and also other authors in different countries, indicates the considerable interest now being shown in the theoretical increase in on-gage yield made possible by the introduction of some form of automatic gage control. Rolling has previously been somewhat of an art but is now undergoing a period of transition from which it will emerge as a science.

In this particular case I would disagree with the title of the present paper. Automatic gage control as I understand it would be a form of control where gage is pre-set by the roller, and that set gage is held automatically throughout the entire coil length. I believe a single stand mill operating in such a manner has been in operation in England since January 1956. The control referred to in this paper is not apparently able to hold gage during the entire thread to run speed period, i.e., it appears to be inherently a steady state control process. Even so the importance of such a control must not be under-rated. The strain on the roller for much of the rolling cycle is considerably reduced and more time is available for maintaining strip shape, etc.

Figure 13 obtained on our 5-stand cold mill shows that extremely accurate gage can in fact be achieved manually under full speed mill operation. About 12,000 ft of strip are covered here with the heavy black lines representing deviations of ±0.001 in. from the 0.010-in. schedule being rolled. The off-gage in the center portion covers a weld between two coils run through the mill at slow speed while off-gage at the right hand side is caused by mill deceleration. The top portion of the chart is the output from an x-ray gage while the bottom portion is the output from a contact type of gage in the same line across the strip width. The difference between the two signals is of interest, particularly the smoothing effect of the longer time constant inherent in this particular x-ray gage.

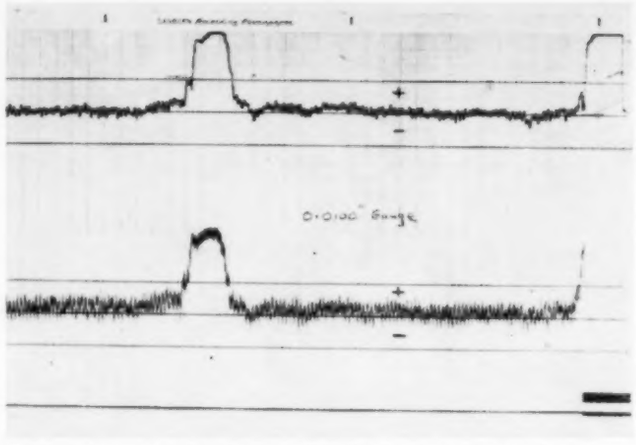

Figure 13 — Very good gage control can be achieved manually under full speed operation. However, compare measurements of top curve made with x-ray gage with contact gage measurement on lower chart.

On the problem of an adequate basis for comparison of the achievements of manual vs automatic gage control, some form of numerical readout equipment will have to be developed capable of accurately measuring the on-gage footage yield per coil as well as the total footage through the mill. These figures will be of value for production control, and will be essential for final adjustment of any automatic gage control system where fractional percentage on-gage yield increases are necessary for economic justification of the equipment installed.

H. S. Maxwell: Automatic gage control is relatively new, and it does not cover every possibility. As it is made more complex, we will be able to maintain more material within tolerance during slow-downs for welds.

Many things are going on concurrently. For example mills are working on improving welding techniques. They do not have to slow down as much for welds as previously. On the four-channel chart shown, the gage went out of tolerance; that is, it was still within commercial tolerance at the weld, but it went out of the band we had drawn on the chart just slightly above the speed at which the weld was brought through. In starting a new strip, we can get on-gage within about half the strip length required without gage control.

A description of the gage control would be—a continuous thickness regulating system for the last stand, a sampling regulating system for the first stand. We hope some day to hold the full length of strip right on gage.

H. Kermit Fish: Before Weirton Steel Co. purchased their last tandem mill they ran many tests on their 5000-fpm mill. One of the things we wanted to know was the percentage of reduction by rolling and the percentage by tension. By using a rheostat on the fifth stand motor we were able to slow down motor and the gage increased. From this and other tests we found we were obtaining 40 per cent of the total reduction in the fifth stand as a result of tension between the fourth and fifth stands.

The automatic or x-ray gages discussed in this paper have been installed on our latest tandem mill and are very successful. Our people have become accustomed to them and use them continuously. The maintenance has been very low.

Basic Hot Blast Cupola as Source of Hot Metal for Steel Plants

By
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. . . . the basic hot blast cupola may be one means of providing hot metal for steelmaking without the construction of additional blast furnaces . . . . interesting possibilities are apparent, particularly for smaller plants when the relatively small investment cost for added capacity is considered . . . . successful operation in German plants has been obtained . . . .

▲ SEVERAL years ago when Germany was faced with the necessity of expanding steel production a number of steel plants investigated the basic operated carbon lined hot blast cupola as a means for supplying hot metal to the open hearths and thus increasing the tonnage in terms of tons per furnace hour. The author's company of cupola engineers adapted the carbon lined hot blast cupola to steel plant requirements and, as a result, a number of plants were built and placed into operation. Other plants are under construction. This paper was prepared for the purpose of calling attention to the possibilities offered by this development and also to distinguish it from the cold blast acid lined cupolas installed in some steel plants in this country in the early forties. The improvements are so extensive that the cupola, as a source of hot metal for steel plants, is now worthy of another look by the American steel industry.

The design principles now employed in the carbon lined hot blast cupola more closely approach those employed in blast furnace construction than those employed in the cold blast cupola with which we are familiar. Water-cooled tuyeres of rolled electrolytic copper of practically the same design as blast furnace tuyeres are used in place of plain pipes or rectangular ducts used in cold blast cupolas. In place of the rectangular wind box employed on cold blast cupolas, circular bustle pipes similar to those on the blast furnace are used.

The carbon lining in the cupola extends only about seven ft above the bottom of the hearth. Above this there is no lining and the charge works against the shell. The shell is cooled by water sprays and tapers outwardly towards the bottom, thus assuring close contact of the cooling water with the shell.

The carbon lining in the hearth lasts indefinitely, with patching around the tuyeres every six to eight weeks at a cost equal to about 5 cents per ton of metal. This is in comparison with approximately 72 to 80 hr of lining life and a cost of about 65 cents per ton of metal for an acid-lined cold blast cupola.

The cupola is tapped continuously. The metal and slag flow into the slag separator, from which the slag flows into the cooling water drain pipe. Here it is granulated by the drain water which carries it into a granulated cinder pit.

The cupola gas is withdrawn from the cupola several feet below the level of the charge which is maintained fairly uniform through stock line recorders. The cupola gas withdrawn passes through a cyclone dust catcher where the larger particles of dust are removed.

Up until recently a cyclone dust catcher alone was used to remove the dust in the gas before the gas entered the recuperator as shown on Figure 1. However, it was found that this did not provide adequate cleaning for steel plant installations using the cheaper grades of scrap and a washer is used in newer plants, as described later.

Through the use of a tubular recuperator designed to burn cupola gas, and also of German design, hot blast temperatures of 1100 to 1200 F are uniformly maintained.

The tube extending down the center of the bank of tubes in Figure 1 admits cold air to the wind box adjacent to the tube sheet. This air is re-entered into the hot air stream in the recuperator. All tubes are provided with expansion joints, as are all hot and cold air connections to the shell. The unit is constructed of special alloy steel designed to withstand air temperatures up to 1400 F. Uniform temperatures are maintained through thermostatic control.

Because of the frequent lancing of the tubes, in order to maintain uniform hot blast temperatures with the installation shown on Figure 1 a washer is now installed as shown on Figure 2.

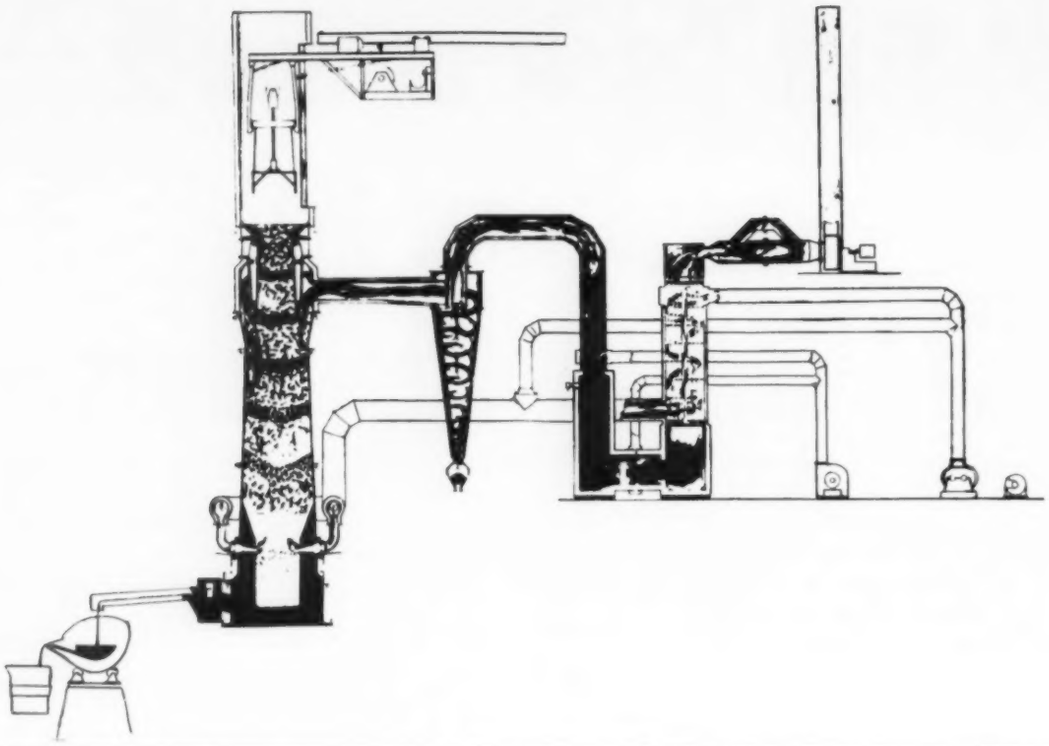
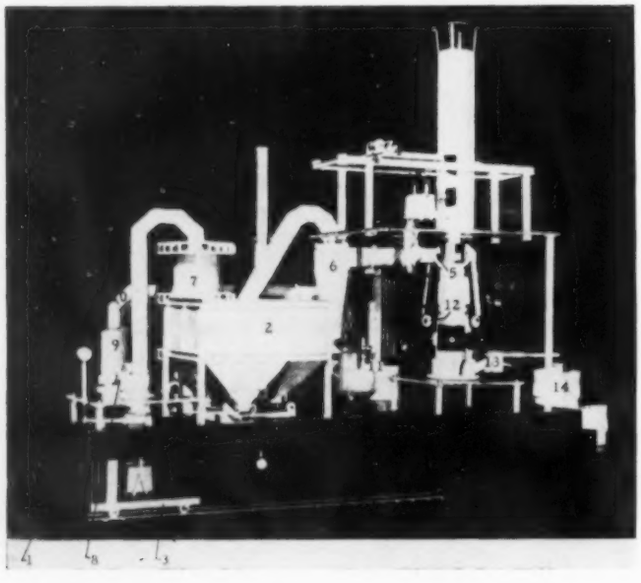


Figure 1 — Layout shows hot blast, carbon-lined cupola without the gas washer which is now used.

In this installation the gas passes from the cyclone dust catcher to a cooling tower, thence to a washer where it is washed and delivered under pressure to a dehumidifier, and thence to a clean gas header. All of the gas is withdrawn from the cupola and no fumes emit from the cupola stack. The gas has a calorific value of about 69 Btu, and about one-third is required for heating the blast. The remaining surplus amounting to about 1,125,000 Btu per ton of metal is available for other uses. With the washer, the recuperator tubes remain clean without lancing and no visible fumes emit from the plant.

Figure 2 — Components of cupola system are as follows: (1) scrap trimming platform; (2) coke and limestone bins; (3) charging car; (4) charging crane; (5) gas collecting chamber; (6) cyclone; (7) cooling tower; (8) washer; (9) dehumidifier; (10) clean gas duct; (11) recuperator; (12) hot blast bustle pipe; (13) slag separator; and (14) mixer ladle.



From the foregoing it is apparent that the changes in design represent broad departures from cold blast cupola practice, and that the carbon-lined basic operated hot blast cupola as now designed more closely resembles a miniature blast furnace than a cold blast cupola.

OPERATION

The difference in operation between the carbon-lined basic operated hot blast cupola and the conventional cold blast acid cupolas installed in some steel plants in the early forties is just as pronounced as is the design, if not more so. This can best be illustrated by a point by point comparison.

1. The hot blast cupola uses a 100 per cent steel scrap charge, whereas the cold blast cupola requires a minimum of 20 per cent iron scrap or pig iron.

2. The hot blast cupola can use the cheapest obtainable grade of scrap including light baling wire, and up to 33 per cent fines, such as turnings and shovelings. The cold blast cupola freezes up on similar charges and is restricted to fairly heavy scrap.

3. The hot blast cupola uses furnace coke, whereas the cold blast cupola is restricted to high priced foundry coke.

4. The hot blast cupola uses 30 per cent less coke than a cold blast cupola on comparable scrap charges.

5. The cold blast cupola requires 10 to 15 lb of ferrosilicon to supplement the coke fuel and to keep oxide loss in the slag within reasonable limits. The hot blast cupola requires no ferro-silicon except when using a very light and poor grade of scrap.

6. The metal from a cold blast cupola must be desulphurized, whereas the metal from a hot blast cupola does not.

7. The carbon content of metal from a cold blast cupola is about 2½ per cent whereas the carbon content from the hot blast cupola is 3½ per cent and

over, thus rendering the metal more effective for open hearth purposes.

8. The temperature of metal from a hot blast cupola is about 150 F higher than metal from a cold blast cupola and hence more effective in increasing open hearth production rates.

9. Metal can be produced in a hot blast cupola at much less cost than in a cold blast cupola and the metal will be of higher quality. The differential in cost, of course, is largely dependent upon the difference in cost between the foundry coke and furnace coke and also the difference in cost between cast iron scrap and steel scrap used.

10. While acid-lined cold blast furnaces cannot be continually operated and at least two furnaces must be alternately fired, the water-cooled, carbon-lined hot blast cupola can be continually operated day and night without interruption and without any serious wear and tear of the refractory lining.

The cost above scrap charge for the carbon-lined hot blast cupola ranges from $6.00 to $7.00 per ton, depending on the grade of scrap used, coke prices and size of plant. This is after credit for surplus gas amounting to 45¢ and is about $3.00 to $4.00 per ton cheaper than the cost above for a cold blast cupola.

EFFECT OF CUPOLA METAL UPON OPEN HEARTH PRODUCTION RATES AND COSTS

One of the first steel plants in Germany to install a carbon-lined hot blast cupola was Walzwerke A-G. (formerly the E. Bocking Plant) in Cologne-Mulheim. After 21 months of operation, during which time records on ingot production and costs were carefully kept, Mr. G. Rockrohr, superintendent of steel production, and Mr. W. Schull, director, delivered a paper before the German Iron & Steel Association. A few pertinent items of interest contained in this paper are as follows:

1. That with a charge of hot cupola metal equal to 45.8 per cent of the ingot tonnage, open hearth production rates were increased by an average of 36 per cent. (This is equivalent to 0.785 per cent increase in open hearth production per per cent of hot metal charged.)

2. That with a 45.8 per cent hot metal charge and the consequent increase of 36 per cent in production, the cost of ingot production was reduced 16.5 per cent. (This is equivalent to 0.458 per cent decrease in ingot cost per per cent of hot metal charged.)

Commenting on the paper given by Mr. Rockrohr, Mr. F. A. Baare of the Hah'nschewerke in Grossenbaum which installed a hot blast cupola in 1952, stated:

1. "The increase in open hearth production at Grossenbaum was 25 per cent with a hot metal charge of 33 per cent. (This is equivalent to 0.757 per cent increase in open hearth production per per cent of hot metal charged.)

2. As a result of the hot metal charge, Grossenbaum now load their open hearths with a tapping weight of 1625 to 1725 lb per sq ft and as a result, the efficiency of the open hearth has increased by 55 per cent."

This is considerably heavier loading than practiced in this country; however, there are some furnaces here with very deep baths.

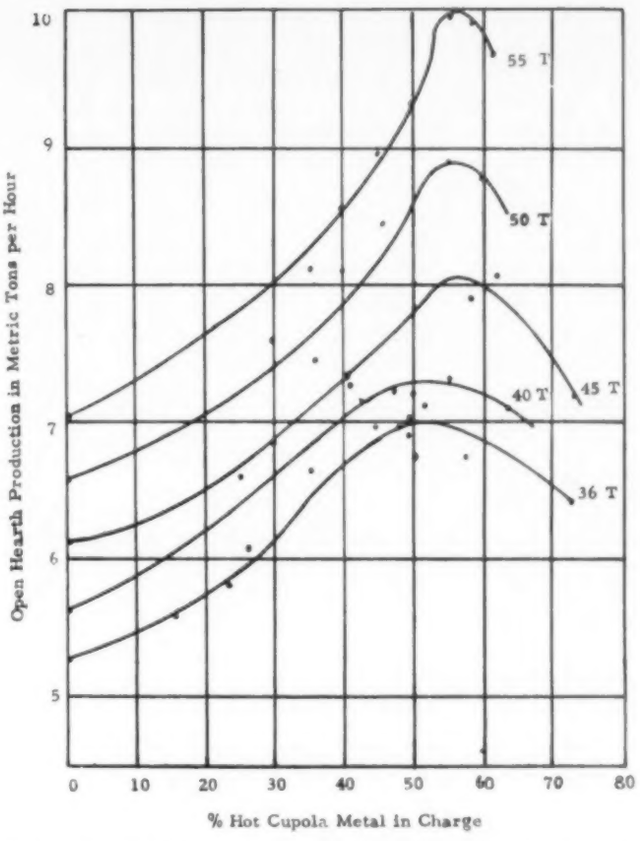


Figure 3 — Open hearth production goes up as per cent cupola metal is increased up to about 60 per cent of metal.

Recent experience in Germany indicates that a 50 per cent charge of molten cupola metal gives the best results. This refers to furnace performance. Because cupola metal is practically free of silicon and manganese, the carbon content of the metal is quickly absorbed by the bath or oxidized, and hence cupola metal can be charged in higher quantities than blast furnace metal.

The effect of varying the percentage of hot metal charge on open hearth production rates is shown by Figure 3. This graph has been reproduced from Rockrohr's & Schull's paper presented before the German Iron & Steel Association which was published in *Stahl und Eisen*. The average size of heats made by the furnace, the performance of which is represented by Figure 3, was 38 metric tons. The graph shows the size of heats was increased to 55 tons with hot metal charges, and the tons per hour increased from 5.3 tons per hour on cold charge to 9.9 tons per hour with a 55 per cent hot metal charge.

ECONOMICS OF THE INSTALLATION

The cost of a carbon-lined, hot-blast cupola plant amounts to about $7.00 per ton of annual capacity. With a hot metal charge of 33 per cent, one-third of a ton cupola metal would be required for every ton of open hearth ingots. Hence the cost of a cupola plant in terms of ingot production would be one-third of $7.00, or $2.33 per ton of ingots for the 33 per cent hot charge used by Mr. Baare at Grossenbaum.

A cold charge open hearth shop under today's prices costs about $42.00 per ton of annual capacity, of which the furnaces and building proper represent about $24.00 per ton.

To increase the number of furnaces in a cold charge shop by one-fourth to obtain the 25 per cent increase in production obtained by Mr. Baare with a 33 per cent hot charge, would cost 24.00 per ton of capacity added. The $24.00 per ton of added capacity distributed among the total new tonnage would be equal to (0.25 × $24 ÷ 1.25) = $4.80 per ton of ingots. In contrast to this, a hot-blast cupola installation for such a plant would cost $2.33 per ton of ingots, or 51.5 per cent less than the cost of additional open hearths, and the cost of ingots would be reduced by virtue of increasing the tons per furnace hour instead of the number of furnaces operated.

To obtain the 36 per cent additional capacity as given by Mr. Rockrohr, a 45.8 per cent hot metal charge would be required and the cost of a cupola plant in terms of ingots produced would be (0.458 × $7.00) = $3.21.

To obtain the 36 per cent additional capacity by adding new open hearth furnaces would cost (0.36 × $24 ÷ 1.36) = $6.35 per ton, or $6.35 − $3.21) = 97.6 per cent more than the cost of the cupola plant.

ECONOMICS OF OPERATION

With the size of open hearth furnaces getting larger and the quality of scrap getting poorer, charging time is a major factor in open hearth production rates. In some cases the grades of steel produced prohibit the use of cheaper grades of scrap because of residual alloys. Although not all of the cheaper grades are contaminated, it is not practical to isolate the objectionable scrap in the scrap yard and hence a premium is paid when uncontaminated scrap is required. It is believed that by premelting these cheaper grades in the cupola, much can be accomplished toward isolating the residual contaminated metal from the uncontaminated metal. Cupolas are built for capacities up to 40 tons per hour and the metal flows from the cupola in a continuous stream. About ten skip loads of scrap per hour are charged through a weigh hopper located on the scrap trimming platform, offering an opportunity for visual inspection of each charge. The stream of metal flowing from the cupola may be sampled and analyzed at frequent intervals. Two mixers may be installed, and the metal can be separated according to analysis. If residuals are running high, select grades of scrap can be used to reduce the percentage contained in the mixer.

For ordinary grades of steel, if the furnaces are to be charged within a reasonable length of time, a quantity of No. 1 heavy melting scrap must be used. Current prices for No. 1 heavy melting scrap are about $60 a ton; No. 2 heavy melting scrap sells for about $10 less; and shovelings, $20 a ton less. Motor blocks other than those of old Fords are practically copper free and sell for about $15 per ton less than No. 1 heavy melting scrap. Stripping of the motor blocks costs about $1.00 per ton after credits for non ferrous metal salvaged. With a cupola charge consisting of

TABLE I

Cost of Cupola Metal

	Per net ton	Lb	Cost	
Metallic Charge				
No. 2 Heavy melting	@ $43.80	510	$11.16	
Shovelings	@ $34.80	510	$ 8.89	
Motor blocks	@ $41.10	1000	$20.50	
Total per net ton		2020		$40.55
Flux and Coke				
Furnace coke	@ $22.00	300	$ 3.30	
Limestone	@ $ 2.50	120	0.15	
Fluorspar	@ $30.00	40	0.60	
Total flux and coke			$ 4.05	
Operating expense—40-Ton per hr unit				
*Supervision and labor			$ 0.44	
Repairs and maintenance			0.24	
Supplies			0.20	
Relining and refractories			0.12	
Water, power and gas and air			0.25	
Switching			0.10	
Scrap prepared @ $1.00 per ton (stripping motor blocks)			0.50	
Works expense (allow)			0.35	
Total operating expense			$ 2.20	
Gross cost above			$ 6.25	
Less gas credit: 1,125,000 Btu @ $0.40 per million			0.45	
Net cost above				$ 5.80
Net cost of metal				$46.35

* With 25-ton unit, labor cost will increase by $0.22 per ton.

25 per cent No. 2 heavy melting scrap, 25 per cent shovelings and 50 per cent motor blocks, the cost of metallic charge amounts to $40.55 per net ton, as shown in Table I.

If a charge consisting of 100 per cent No. 2 heavy melting scrap is used, the yield would be 100 per cent. However, because of the higher price scrap, the cost of metallic charged would be $43.55 per net ton instead of $40.55 as shown on the preceding cost sheet. It is apparent that whether the cost of charge of the open hearth is raised or lowered by the use of cupola metal depends upon the type of charge used in the cupola and the charge practice in the open hearth.

Offsetting any increase in cost of charge, if it occurs, is a reduction in open hearth cost above. Messrs. Schull's and Rockrohr's curves, reproduced here as Figure 4, show the increase in tonnage and the decrease in cost above metallic for varying percentages of hot cupola metal charge. Mr. Rockrohr states that with a 45.8 per cent hot metal charge, their cost above was reduced 16.5 per cent. From a number of analyses made on U. S. plants, 40 per cent hot cupola metal seems to give the most economical operation.

In summation, it appears that with the prospect of $60 scrap remaining with us for some time to come and with the lighter grades selling for $10 to 20 less, some means for substituting cheaper grades without sacrificing tonnage and quality is deserving a serious consideration. Sulphur contamination in turnings can be overcome by desulphurizing the cupola metal. This is not normally required with the basic hot blast cupola.

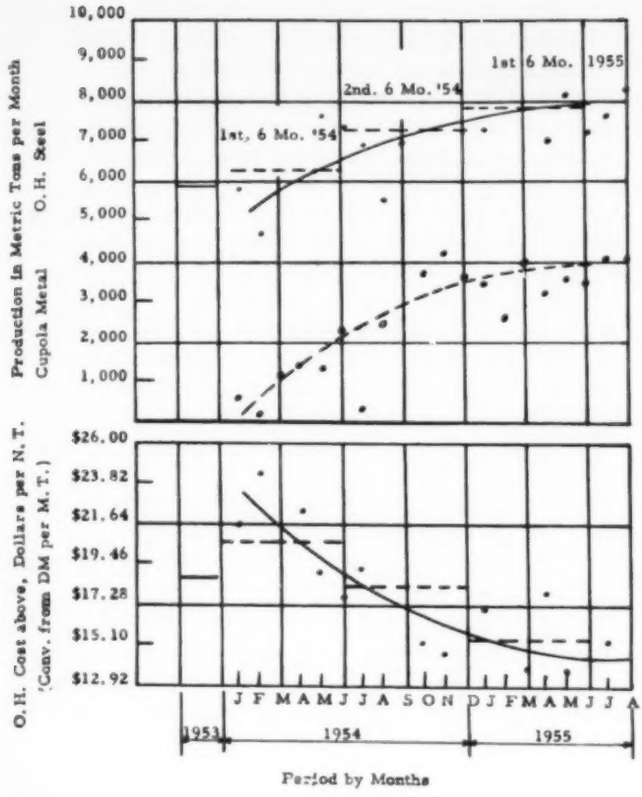


Figure 4 — Open hearth costs above can be markedly reduced with hot cupola metal charges.

CUPOLA METAL FOR ELECTRIC FURNACES

While the scrap problem for the electric furnace is not so serious as for the open hearth, the problem of contamination does exist. Mr. Rockrohr has done considerable work in the application of decarbonized cupola metal to electric furnaces. Figure 5 is a reproduction of the graph prepared by Messrs. Schull and Rockrohr. This shows an oxygen lance inserted in a ladle of cupola metal after adding an extension to the ladle to simulate an oxygen converter. The curves on the graph show the quantity of oxygen required to decarbonize cupola metal for charging into electric furnaces. This quantity is shown to be about 1275 cu ft, or 114 lb of oxygen per net ton of cupola metal.

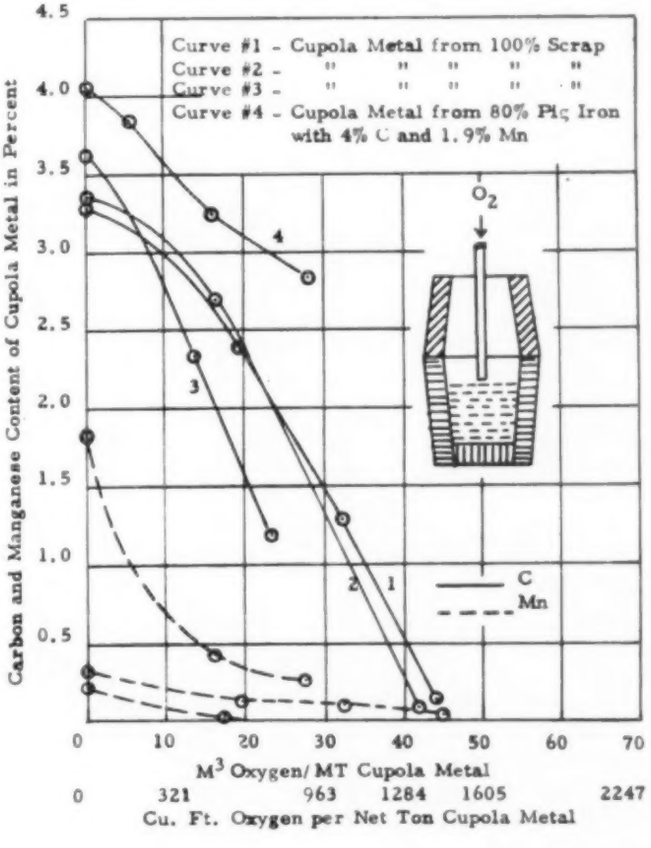
In this connection, by using decarbonized cupola metal, hot metal open hearth shops could practically eliminate cold scrap charges and save two hours or more per heat. This would materially reduce not only operating cost but fixed charges per ton of annual capacity as well.

Some months ago, subsequent to the presentation of Mr. Rockrohr's paper, the practice of inserting the oxygen lance directly into the electric furnace was established at Mr. Rockrohr's plant in Cologne-Mulheim where a six-ton electric furnace is installed. The practice is first, to charge 50 per cent cold scrap and second, to add the hot cupola metal to make up the remaining 50 per cent. The oxygen lance is then withdrawn and the electric current turned on. The reduction in power consumption is about 33⅓ per cent and the time of heats is reduced by 38 per cent. The oxygen consumption for this type of operation is 866 cu ft, or 77.4 lb per ton of ingots. With oxygen at $10 a ton, the cost of oxygen would be 39 cents per ton of ingots. There should be a reduction in electrode consumption and furnace refractories corresponding to the reduction in time of heats and power consumption.

OXYGEN CONVERTER—CUPOLA METAL

Another use for the basic operated carbon lined hot blast cupola is to supply hot metal for the oxygen converter. While there are oxygen converter plants in this country, they are used in connection with blast furnace metal. While the oxygen converter is a very low cost installation and low cost operating unit, a blast furnace is beyond the reach of many producers. The basic hot blast cupola solves the problem of hot metal supply for the oxygen converter plant at a low capital cost. The combination of basic hot blast cupola and oxygen converter plant ranks among the lowest in capital cost and production cost for ingot producing facilities. With an installation of this type, up to 17 per cent scrap can be charged directly into the converter. One such plant is under construction in Witten, Germany, the cupola plant was placed in operation in August, 1956, the converter plant will be in operation in the spring of 1957. Other plants are in the planning state in this country. This development can easily turn the direction of ingot producing facilities installed in the future from the heretofore conventional methods to one involving a much more modest capital expenditure and lower production cost.

Figure 5 — Amount of oxygen required to decarbonize cupola metal for charging into electric furnaces.



DISCUSSION

PRESENTED BY

WARREN E. HART, Superintendent, Electric Furnace Building, Ford Motor Co., Dearborn, Mich.

K. C. McCUTCHEON, Assistant to Vice President, Armco Steel Corp., Ashland, Ky.

W. R. JAESCHKE, Consulting Metallurgical Engineer, Whiting Corp., Harvey, Ill.

SIEGFRED TUNDER, Vice President and General Manager of Operations, GHW (Gesellschaft fur Huttenwerksanlagen, m.b.H.), Dusseldorf, Germany

Warren E. Hart: It has been pointed out a source of hot metal for open hearth furnaces that are not run in conjunction with blast furnaces is desirable, and we all know that a supply of hot metal increases open hearth tonnage.

At the Ford Motor Company we have an adequate supply of hot metal from our blast furnaces. However, a great deal of work has been done in our foundries with water cooled cupolas both in this country and at our English plant. We consider the water-cooled hot blast cupola a universal cupola, by that is meant you have a great deal of flexibility. You can either run it as an acid cupola or a basic cupola or even as a neutral cupola, depending upon the raw materials and the type of iron you want to produce.

Hot blast is a coke saver, with as low as 500 F hot blast temperature one can save over 15 per cent on the coke charge. Higher blast temperatures will increase these savings as the authors stated (30 per cent for 1100 F).

As far as hot blast is concerned we are just starting to appreciate its advantages as we go to higher temperatures.

I agree with the authors that at 1100 F, oxidation losses are very low.

A major advantage with this type of cupola is that it can be operated continuously for long periods of time, as much as 30 days before any shutdown is necessary for repairs to the carbon lining.

This is a vast departure from the conventional cold blast acid lined cupolas which must be shut down and the lining repaired after every 24 hours run.

Where high production is necessary, it is debatable that blast furnace coke at $10.00 less per ton has any economical advantage over foundry coke. In the first place you are buying heat units in coke in the form of carbon.

The fixed carbon in blast furnace coke is around 88 to 89 per cent while the foundry coke runs at our plant around 92 to 93 per cent carbon. This increase in carbon is a great advantage to the cupola operator for the following reasons:

1. Less coke for equal amounts of heat units.
2. Coke is a bulky material, and with less coke the cupola stack has a greater amount of metallic charge which increases the melting rate.
3. Blast furnace coke has about 3 per cent more ash which would require a greater amount of limestone flux, thus producing considerable more slag for which more heat units per pound is necessary than for the melting of an equal amount of iron.

Great strides are being made with hot-blast, water-cooled cupolas and greater progress is expected when one will be able to utilize all the heat available from the top gases attaining still higher blast temperatures.

This will come about when materials are available that will withstand these elevated temperatures.

K. C. McCutcheon: I have been familiar with the operation and use of hot blast cupolas for a number of years. When I was in Germany, in 1951, Mr. Eric Loh, in the Iron and Steel Institute in Düsseldorf, mentioned it as one of the important developments in Germany.

In 1954, when in Germany on another matter, I visited the installation of Hah'nschewerke in Grossenbaum and the Mühlheim installation mentioned in this paper. I found great interest in Europe and the British Isles in the hot blast cupola for steel plants and for foundries.

In their paper they have described, in good fashion, the advantages in using a hot blast cupola.

If an open hearth plant is already using molten metal, melted in a cold blast cupola, it can be adapted to hot blast at considerably less capital expense than if everything must be furnished. Using 900 to 1200 F blast heat, the coke consumption can be reduced 30 per cent or more, and a hotter, lower sulphur metal without desulphurizing can be produced with higher metallic yields, and with up to 30 per cent increase in cupola output, using 100 per cent steel scrap. The metal cost will depend upon cost and kinds of scrap available and should be lower. There should be some increase in steel production due to more available hot metal and higher temperature hot metal. A computation of comparative cost can be made for any location.

In an open hearth plant which is melting all cold charge when an installation of hot blast cupola is made, the increase in ingot production should be considerable. The curves show increases of from 32 to 42 per cent at 50 to 55 per cent cupola metal in the charge. How much the production is increased will depend principally upon how much metal is supplied, and other things. You can be sure of one thing—the operators will find their charging problem much relieved when the hot metal is supplied. Savings along the lines they have indicated from lower material costs can be figured for the location in question and, if the additional ingot production is needed, the credit figured from this, the saving in cost will be considerable.

In each of these comparisons, the capital charges for increased production should be far lower than for increased capacity from building new open hearth furnaces.

The charts which the authors have reproduced from the paper by Rockröhr and Schull are for rather small furnaces but the results indicated will probably be applicable to larger furnaces. It should be understood that actual results obtained will depend upon what further provisions are made for charging and tapping facilities, besides installing the cupola operating facilities. Increased production rates for increased pro-

portions of molten metal should be about as these indicate.

I believe that their statement that "cupola metal can be charged in higher quantities than blast furnace metal" may be misunderstood, for it is well known that blast furnace metal can be charged in almost any proportion. If the iron is hotter, and lower in silicon, manganese, carbon, it should take more iron to melt in without ore.

Increased production rates for increased heat size will also result about as shown. I would like to comment on the author's statement that, at Hah'nschewerke, with cupola metal, they are charging 1625 to 1725 lb per sq ft. This is far more than is practiced in the USA, and it may be due to the method of figuring areas in the USA.

The lowest sq ft per ton of which I have heard here is 1.97 sq ft per net ton, which figures 1015 lb per sq ft of hearth area. The average will probably be about 3.5 sq ft per ton, or about 575 lb per sq ft, and I have heard of furnaces where the charge is 5 sq ft per ton, or 400 lb per sq ft. In this comparison there must be some difference in figuring. In the USA, the hearth area used is that inside brickwork at sill level.

The larger hearths are generally preferred because, with them, for a given size heat, the charging rate, production rate, and fuel consumption will be more favorable.

It should be interesting to see a complete figuration for the use of hot-blast, cupola metal used to make steel in oxygen converters, compared with other methods.

The use of decarburized hot blast cupola metal in door-charged electric furnaces would undoubtedly increase their output considerably.

The practice of charging the metal directly into the electric furnace, and treating with oxygen offers interesting considerations, also. In 1951, at Gerlafingen, Switzerland, in the Von Rollschen plant, I saw molten pig iron, which had been made in a Girod electric shaft furnace using a large proportion of low grade scrap, charged into a 15-ton arc furnace, and then treated with oxygen lance. It is interesting to relate that this furnace had been top-charged for many years. The scrap was charged from a hopper, the roof was put on, the current switched on, and oxygen used for about forty-five minutes with the furnace tilted forward to allow the oxidized slag to run out. Then, they stopped lancing and shaped up to tap. They reported considerable production increase, and saving in power, but some increase in refractory and repair cost. In this, as in all other operations, the results that will be secured will depend upon numerous considerations. They found it favorable for their conditions. The president of this company is Professor Robert Durrer, who has been connected with many notable advances in metallurgical practices in Europe.

W. R. Jaeschke: There have been some references here to the acid cupola as used in the foundry, as compared to the newer water-cooled hot-blast cupola being proposed for steel mills. We have both types in the foundry industry and we have both types in the steel mill industry in this country. One of the differences that maybe ought to be explained, is that the foundry cupola is generally used strictly as a remelting unit. The problem in the foundry is to produce metal suitable for castings, as cast, to very rigid specifications.

The most logical way to achieve that goal is to start with materials of relatively well-known composition and melt them in a manner in which there are the fewest number of metallurgical changes in the furnace. That is achieved in the foundry industry largely by choosing the better grades of pig iron and better grades of scrap, and melting in an acid cupola with very few if any slag reactions.

Now, the market condition is getting bad on metal. Scrap is getting worse, and very expensive, and is getting very scarce so we must use what we have. In order to use these poorer grades of scrap, there is more need to use preheated air to protect that metal in melting against excessive oxidation losses. As the ratio of the surface area to mass is increased in the charging stock in the cupola, there is an increased rate of oxidation. To protect that metal against this excessive oxidation it is advisable to use preheated air, or an excessive amount of coke. In this case, the preheated air is not primarily used for fuel economy.

Tests at one of our research institutes indicates that the savings due to preheated air are not a straight line function of the air temperature, and that the rate of savings drop off as the preheat temperature rises. This is possibly due to the fact that as the air temperature rises and the temperature of combustion increases, the reaction of carbon with CO_2, producing CO, increases. Inasmuch as this is an endothermic reaction, a point may be reached when as much heat is consumed in this reducing reaction as is obtained by increasing the blast temperature.

One thing to remember about air preheaters is that the materials of construction for those units depends on the temperature of preheat. For temperatures above 750 F in a preheater, better materials of construction than ordinary plain carbon steels are required. Plain carbon steels begin to lose properties very rapidly at about that temperature, so for higher air temperatures than 750 F, alloy steels are required, or refractory lining to protect those units that are not built of alloy steel.

There is, as Mr. Hart mentioned, a question about the economics between blast furnace coke and foundry coke. In the foundry industry we have found that besides the carbon content, the size and the strength of the coke is very important so far as the thermal efficiency is concerned—and in order to operate a cupola for maximum tonnage rate we must operate it for maximum thermal efficiency.

We have in the foundry industry, in cases where the highest temperature is not required and where no processing is done, high pig iron charges used and with the good foundry coke melted at a ratio of 16 to 1. That is about 6¼ per cent of fuel. In an 87-in. cupola of that type we have produced as much as 62 tons an hour. As to the type of cupola shown in this paper; with 1000 F hot blast, using inferior coke and inferior type of melting stock—high coke consumption is required to promote highly reducing conditions to produce iron of low sulphur content. Such conditions result in low hourly melting rates. From such a cupola of 90 in. inside diameter only 18 to 20 tons per hour are obtained.

It is not possible to obtain maximum thermal efficiency, and highest melting rate, when the poorest

types of material are used. Some of these conditions are unavoidable; if we must use the low grade scrap and coke, we should use them under reducing conditions. That means a lot of coke, a lot of preheat, and low melting rates.

Siegfred Tunder: Mr. Jaeschke is correct in stating that the cupola furnace was originally strictly a remelting unit for the foundry. It is comparatively easy to achieve a high melting rate in a large acid-lined cupola furnace by selecting first class charge materials such as high quality pig iron and cast iron scrap with steel scrap free from sand and rust and by using a large sized hard foundry coke. But even when such material is readily available at reasonable prices, this method would not be suitable for preparing a hot metal for charging in a steel plant. The sulphur and silicon content of the metal would be too high and would necessitate a long boiling period in the open hearth.

The poor quality of the material available for charging in Europe has for some time encouraged the development of continuous smelting in a basic cupola furnace. By this method, it has also been possible to eliminate the oxides and contaminations in the charge materials used in the foundries through the basic slagging practice and the reducing atmosphere. It has been demonstrated that the quality of the completely gas-free cast iron obtained with basic slag has exceeded all expectations for cupola furnace metal.

This fact encouraged the development of the hot blast cupola furnace in recent years to the point where it can operate continuously without any danger of breakdown. The manufacture of recuperators using alloyed steel for blast temperatures of considerable magnitude is today no longer a problem. The somewhat higher coke rate necessary for the production of a reducing atmosphere pays for itself by the fact that the top gas can be used for preheating the blast and the consequent production of a better quality metal. It is only with a water-cooled, basic-operated, hot-blast cupola furnace that a high quality iron with low silicon and sulphur, which is welcomed by the steelworkers as a suitable liquid charge, can be produced from 100 per cent medium and low grade scrap.

We can inform Mr. Hart that, with the present technical experience, a water-cooled, carbon-lined, cupola furnace can be kept in uninterrupted operation for two to three months without any repairs to the lining. The repairs which are necessary after this period are confined to the lower part of the furnace below the tuyeres and can be carried out during the week-end.

Experience has shown that with the correct furnace height, the top gas temperatures are so low that the construction parts of the furnace are not subjected to any deterioration in physical properties. The top gas produced can be fully used after cleaning. While one-third of the total quantity is required for preheating the blast, two-thirds remain available for other uses in the plant.

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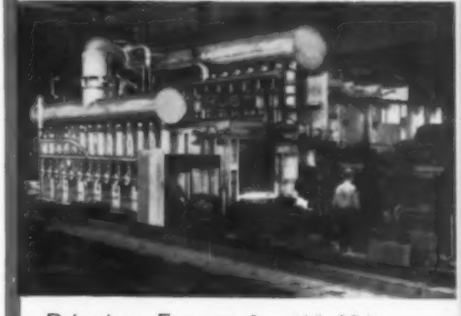

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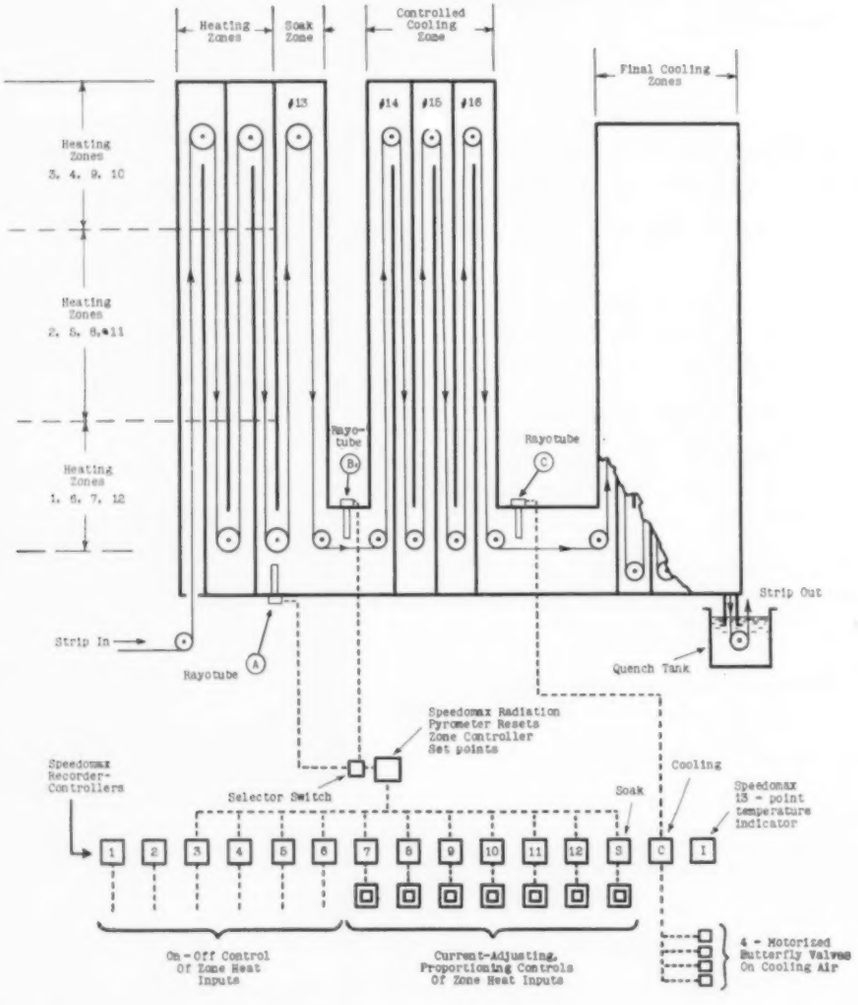
RE-

Cascade System Gives Precise Temperature Control on Continuous Strip Annealing Line

▲ IN continuous annealing of steel strip for tin plate, The Steel Company of Canada, Ltd., of Hamilton, Ontario, encounters frequent load changes due to varying speeds, and different widths or thickness of strip. To hold annealing temperature precisely with such load changes, they employ a unique interlocked instrument combination, known as "cascade control." This control, part of a complete temperature control system designed by Leeds and Northrup Co., uses a radiation pyrometer to rapidly detect the effects of load changes and reset individual zone controllers—thereby permitting temperature control within narrow tolerances on a completely automatic basis.

Figure 1—Schematic diagram shows complete temperature control system on continuous strip annealing line at Steel Co. of Canada, Ltd.



The complete L&N temperature control system, shown schematically in Figure 1 and in the panel photograph (Figure 2), represents one of the most advanced installations for high speed continuous annealing lines. In addition to cascade control of zone heat inputs, a similar system measures and controls the exit strip temperature from the controlled cooling zone. The Steel Company of Canada justifies this extensive instrumentation on the basis of its high degree of flexibility in maintaining quality, tonnage production in the face of the operating variables. Heating costs are minimized and maximum production rates assured.

The electrically heated furnace, designed and constructed by Drever Co., has an installed input of 3000 kw for a rated production of 37,000 lb per hr with 32 gage strip, 33 in. wide, running at 550 fpm. It normally handles strip in gages from 35 to 25 and in widths from 19 to 38 in. The furnace is provided with a protective atmosphere to insure a clean strip which does not require pickling prior to tin plating.

HEATING AND SOAK ZONE CONTROLS

As shown in Figure 1, the strip travels up and down a distance of

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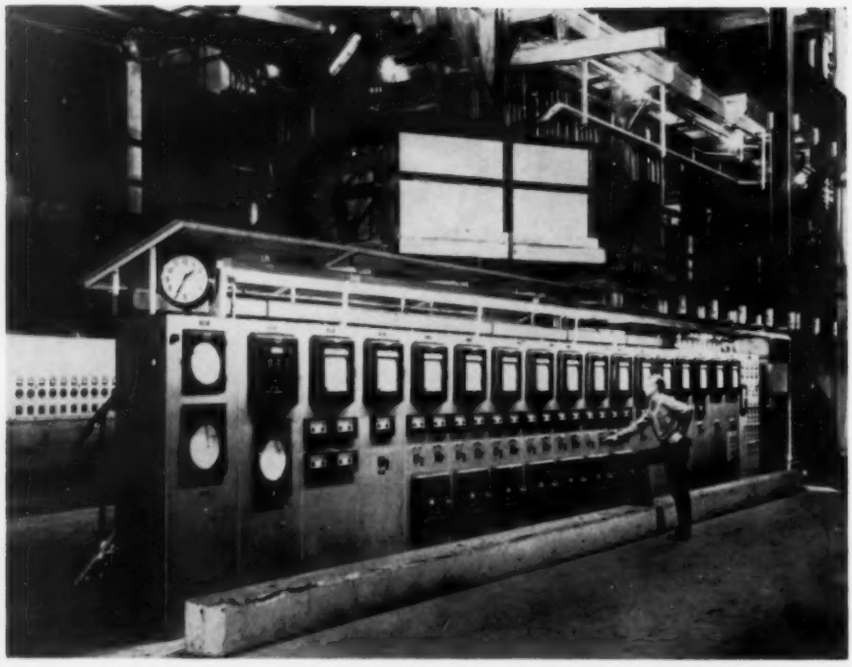


Figure 2—Panel of temperature recorder-controllers and associated instrumentation for entire line.

some 42 ft through 12 individually controlled heating zones. This is followed by a soak zone, a controlled cooling zone, a final, uncontrolled cooling zone, and a quench. For the heating and soak zones, strip chart speedomax recorder-controllers measure the zone temperatures with chromel-alumel thermocouples installed through the furnace walls (see Figure 3). These instruments regulate current input to electric heating elements in each zone.

The two controllers for zones 1 and 2, are not reset from the master radiation pyrometer because the furnace uses maximum input to heat entering strip. These controllers employ a more precise type of control: L&N's "CAT" (current-adjusting, proportioning with automatic reset and rate action). This control regulates the temperature through saturable core reactors.

CASCADE CONTROL

As shown in Figure 1, one radiation detecting element (rayotube *A*) sights directly on the strip as it leaves the last heating zone. It is sighted up through the furnace bottom as shown in Figure 4, measuring the actual temperature of the moving strip. Similarly, a second rayotube (*B*) measures the strip temperature as it leaves the soak zone. Under normal operation, both temperatures should be identical and only one is used, through a selector switch, to reset the zone controllers. The operator can occasionally switch to the unused rayotube for a check of temperature at the alternate point.

A speedomax recorder-controller logs the selected strip temperature and electrically adjusts the set points of heating zone controllers *3* through *12*, and also the soak zone temperature controller. If, for example, the strip temperature starts to drop below its set point (possibly because of an increase in rate of strip travel), the master controller automatically starts to raise the set points of individual zone controllers. This increases the heat input to balance the greater load and quickly brings the exit strip temperature back to its set point.

Flexibility in the automatic adjustment of control set point is provided in that relative changes of the motorized set points on each zone controller are individually adjusted so that each responds to the master controller's command by the desired amounts. In this manner, the control system is "tuned in" to exactly balance load changes as they occur; this resulting in a fully automatic temperature control system for the line.

CONTROLLED COOLING ZONE

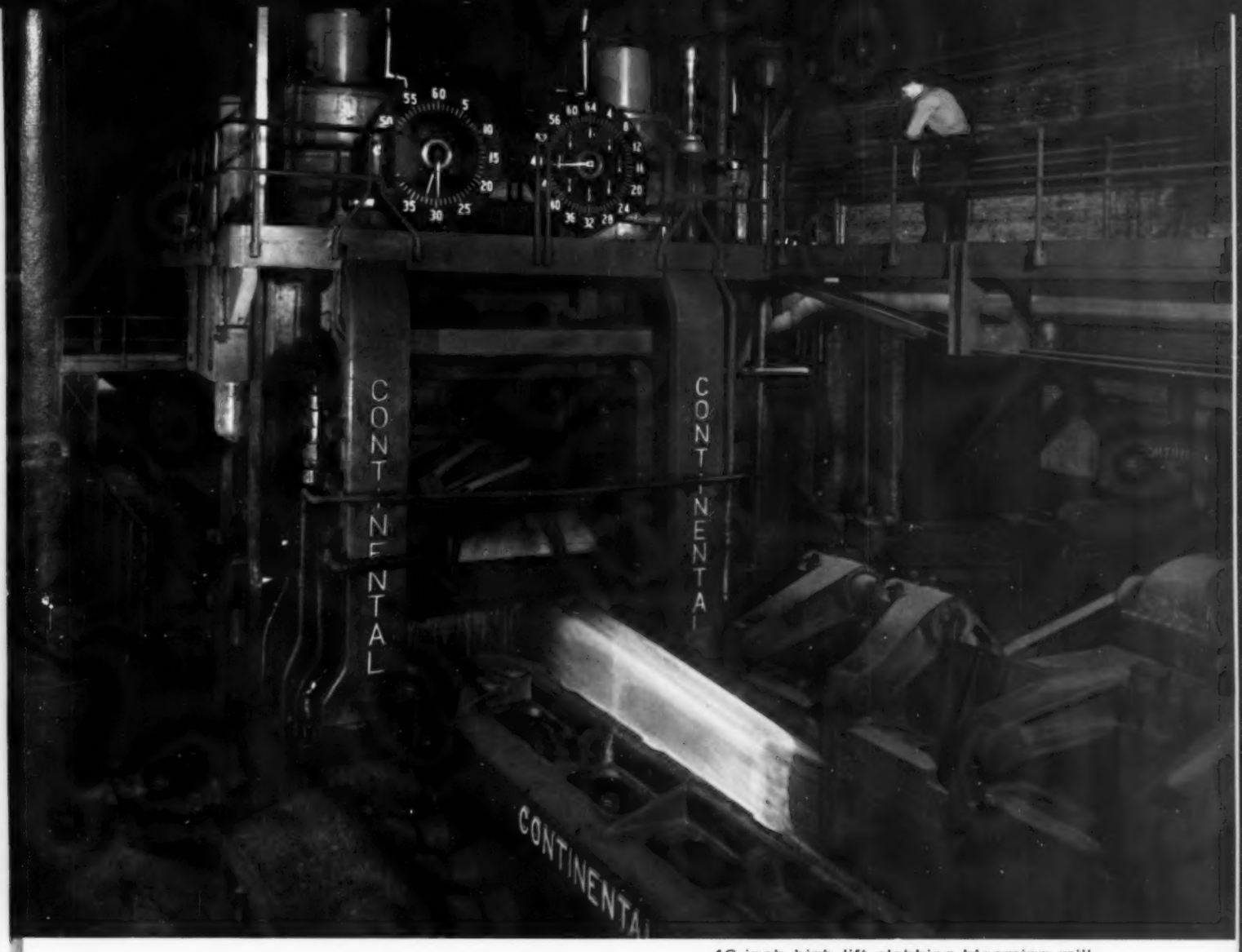
A third rayotube sights on the strip as it leaves the controlled cooling zone. This temperature measurement is recorded by a strip chart speedomax recorder-controller. The instrument has proportioning type electric control which operates four electric drive motors to position four butterfly valves on separate cooling air lines. Electrical bias adjustments on the drive units permit variation in the relative amounts of cooling air to each section of the zone.

Figure 3—Thermocouples are installed through side wall of the annealing furnace, measuring individual zone temperatures. Note air connections for pressurized protection of thermocouple.

Figure 4—Radiation detector element sights up through furnace bottom to measure temperature of strip as it leaves the last heating zone.

INDICATOR FOR TEMPERATURE CHECKS

A speedomax Model D Indicator (panel-mounted near left-end in Figure 2) has parallel connections to each of the 13 thermocouples to permit centralized checking of temperatures in the 12 heating zones and the soak zone.



46-inch high lift slabbing-blooming mill

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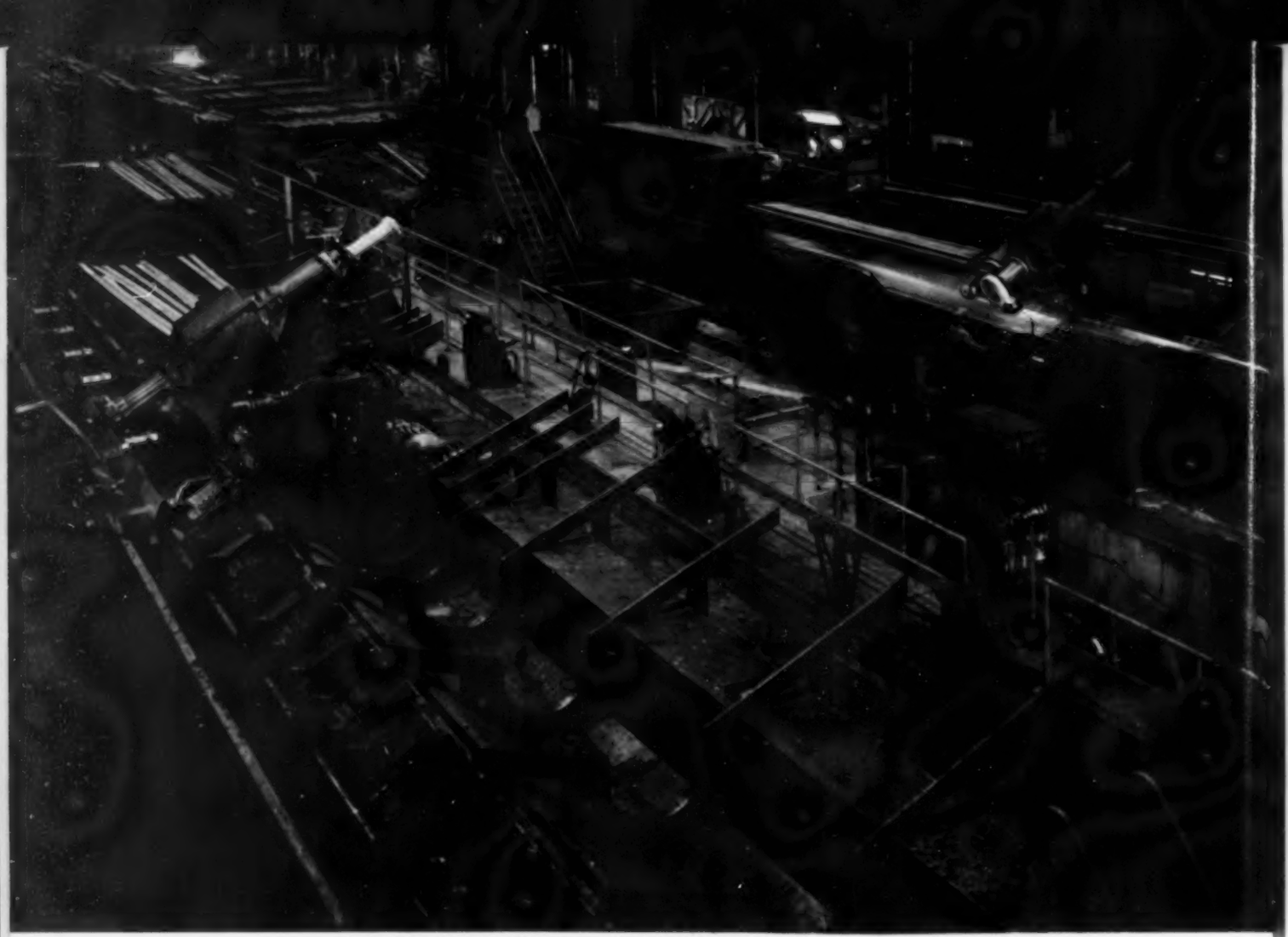

The Continental Billet Conditioning System provides straight through work flow from raw billet inspection to chipping and discharge

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increases chipping production, cuts handling time

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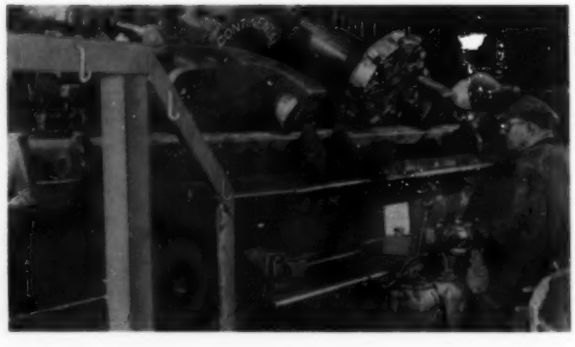
Product quality improvement is immediate, positive. Precise chipping is accomplished by a non-traveling cutter head under which the billet moves in a fashion similar to a milling machine. All chipping is done at close range, immediately in front of the operator. This single operator, located in front of the cutter head controls the entire operation including all material handling.

The chipper is equipped with special interlocking devices which eliminate unsafe operation.



Usual chipping bay hazards such as high pressure air lines, improperly handled chisels, and flying chips are removed. The Continental Chipper accommodates billets up to 30 feet in all merchant and bar mill sizes.

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Packaged Power Reactor Put in Operation

▲ THE army package power reactor (APPR), a 2,035-kw pressurized-water nuclear electrical generating plant, was built at Fort Belvoir, Va., by Alco Products, Inc., under contract to the U. S. Atomic Energy Commission for the U. S. Army. It is the Army's first undertaking in the power reactor field. The net electrical output of the plant will be utilized to supplement the Ft. Belvoir power distribution system.

The original design study by the Oak Ridge National Laboratory was for a reactor to meet needs of remote military bases. Certain design requirements were modified to adapt the APPR to permanent construction in a populated area of the United States.

The chief modification hinged on the need to provide a greater measure of safety, and the addition of facilities to adapt the APPR as a training installation. Alco's contract to build the APPR was the first U. S. Government fixed-price contract for a nuclear power plant. It was awarded December 10, 1954. Ground was broken October 5, 1955.

Stone and Webster Engineering Corporation was the engineer-constructor for Alco.

THE APPR SYSTEM

The pressurized-water concept has been proven in the submarine Nautilus, which has logged thousands of miles of operation on its nuclear power plant. The APPR design also has undergone zero-power tests at Alco's criticality facility, Schenectady, N. Y.

Tests of APPR components performed at the criticality facility are credited with having trimmed about six months off the estimated completion time of the Fort Belvoir installation.

HOW IT WORKS

Pressurized water circulates through the reactor, is heated, and passes to a heat exchanger where it transfers its heat to water in a secondary loop. This heat converts the secondary water to steam which is then used to drive the turbine.

The concentrated heat provided by the nuclear system is so great that engineers estimate the weight of coal required to generate an equivalent amount of heat for one

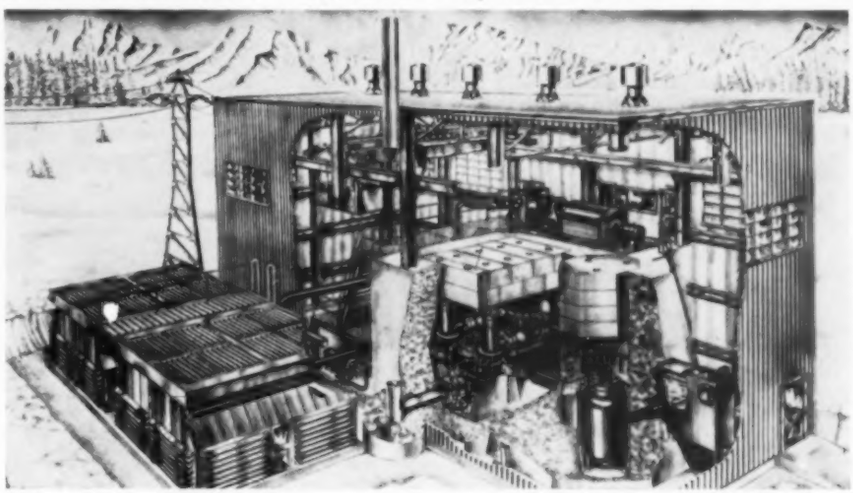
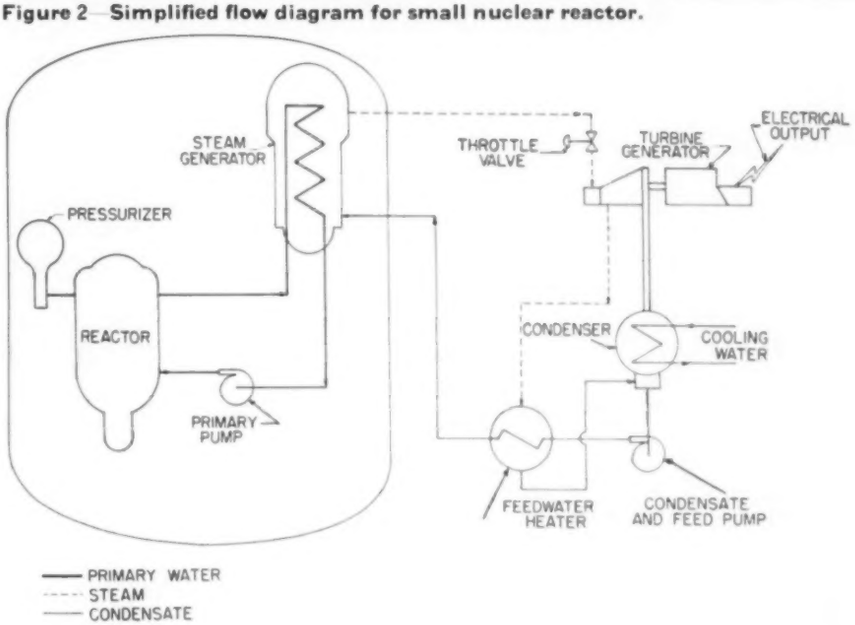


Figure 1—Cutaway view shows various components of package nuclear power reactor.

Figure 2—Simplified flow diagram for small nuclear reactor.



year of operation would exceed some 24,000,000 lb, or several times the total weight of the APPR plant. Nuclear fuel burned in a corresponding period of operation will approximate 11 lb.

THE NEW ASPECT

The APPR has a net power output of 1855 kw. Of the total 2035 gross output, 180 kw are required for plant auxiliaries. The APPR could provide power for a community of 2000. Although electric power has been produced by several other Atomic Energy Commission reactors, this plant is unique in several ways.

It is the first complete integrated generating plant using the pressurized water concept.

It is also the first power reactor using stainless steel-clad fuel, with light water as the coolant and moderator.

In addition to opening a new chapter in the military application of nuclear energy, the APPR helps set the foundation for future civilian uses of the relatively new power source.

Just as the Atomic Energy Commission and the Army expect to develop smaller reactors as power sources in remote areas, similar civil uses are reaching the stage of practicality in areas where conventional fuel is a supply problem.

Alco has also designed a 10,000 kw nuclear-power station, based on the APPR system. This entirely civilian power reactor is designed to serve a community of 10,000.

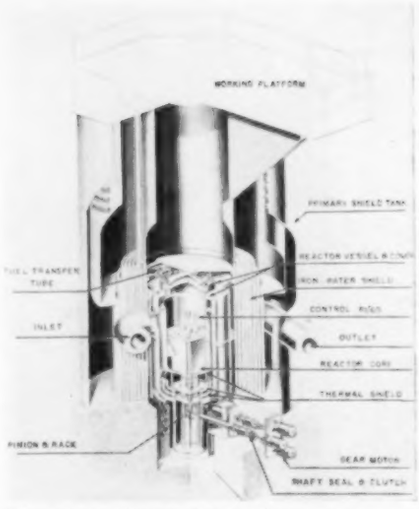


Figure 3—Illustration shows five control rods, whereas actual APPR core normally has two additional safety rods which are usually in the fully withdrawn position.

Nation's Highway Program Suggests Expanding Market for Wire Makers

▲ AN experimental 600-ft stretch of highway that may have a revolutionary effect on present methods of highway construction has been built in Pittsburgh by Jones & Laughlin Steel Corp.

The project represents one of the first full-scale efforts on the part of private industry to find a solution to this phase of the nation's pressing highway construction problem, and is especially timely in view of the Federal Government's new $37,000,000 highway construction program.

In September, 1956, after several years of planning, a level roadbed was graded near the Graham Laboratory for J&L Research, on a 742-acre site in the City of Pittsburgh. The experimental roadway is of pre-stressed concrete design. The pre-stressing operation was carried out in February, 1957. Extensive tests on the roadway will be carried out in the coming months.

The idea for the experimental roadway was suggested by Admiral Ben Moreell, chairman of the board of Jones & Laughlin, who has been interested throughout his career in the mechanics and applications of concrete.

The advantages of pre-stressed concrete have been known for some time, and numerous bridges and other structures have been built of pre-stressed concrete. But the technique of pre-stressing concrete for highway use has been a baffling problem that has been relatively unexplored in this country. Most authorities concede that, in theory at least, a pre-stressed concrete highway would have many advantages over a conventional road. The problem has been to find a practical and economical method of building it.

Essentially, the J&L experiment consists of anchoring connecting wire strands at opposite ends of a 400-ft section of roadway to be formed. The strands pass through flexible steel conduits which are imbedded in the concrete.

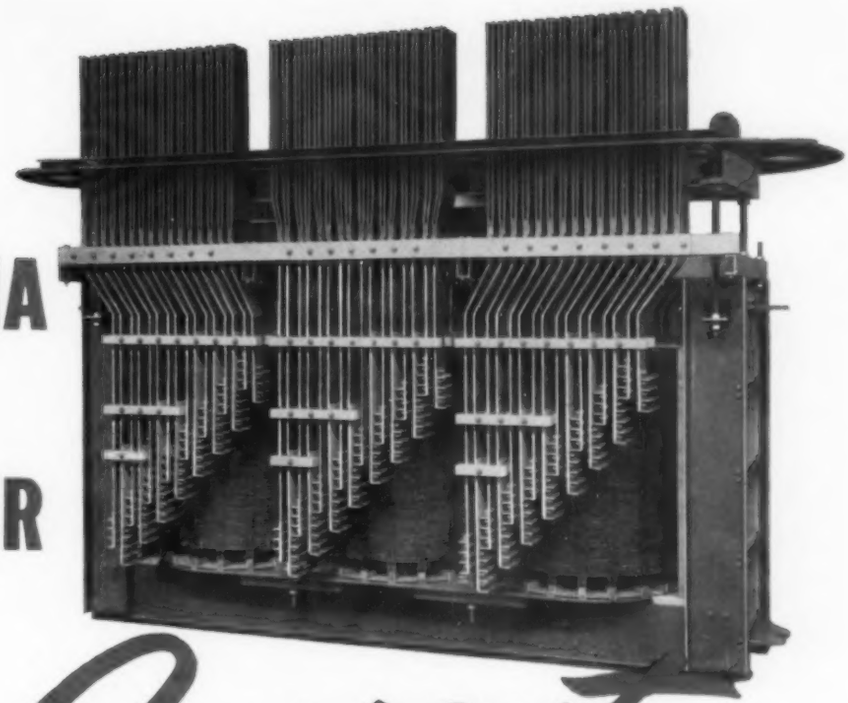
When the concrete for the pre-stressed section was poured, a six-ft gap was left in the middle of the section. For the pre-stressing operation, huge hydraulic jacks were placed longitudinally in the gap. When the concrete set, the gap was jacked apart to a width of 8 ft, or far enough to produce the required tension in the wire strands, and consequent compression in the concrete.

When this was accomplished, the jacks were removed (a special device was developed to hold the sections apart while this was done) and concrete was poured into the gap.

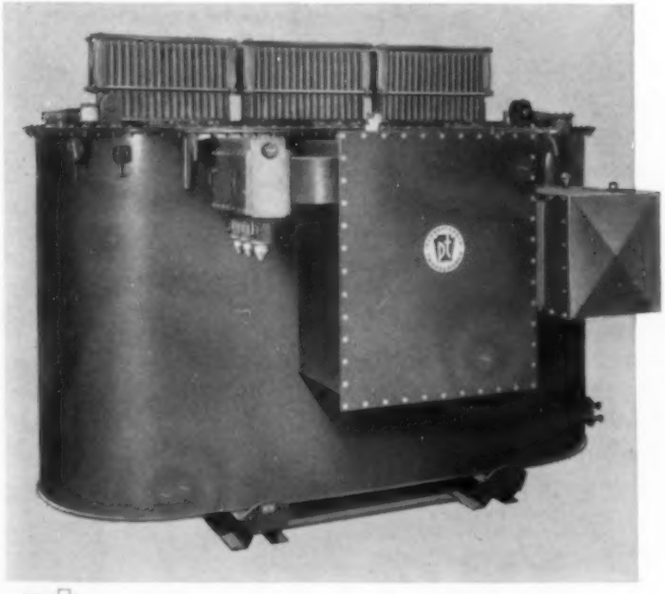
Thus the entire 400-ft section of concrete was placed in compression as a result of the tension in the imbedded steel strands. The concrete slab is 5 in. thick whereas most present-day highway pavements are 10 in. thick. The experimental pre-stresssed highway is designed to overcome one of concrete's inherent disadvantages, its weakness in tension.

The J&L pre-stressed section of 400 ft eliminates seven joints in every 400 feet, or seven places where deterioration could take place. The

Does this PENNSYLVANIA FURNACE TRANSFORMER set a *High Current Record?*



Investigation seems to indicate that it does — but record or not, the 82,000-ampere low voltage line current for which the unit is designed definitely is one of the highest current ratings ever provided for a furnace transformer in this country.



This extremely high current can be delivered at the future transformer rating of 21,300 kva. Now rated at 16,000 kva (with a maximum L.V. line current of 61,600 amperes), the three-phase unit has provisions for the addition of forced-oil cooling equipment to supplement the present water cooling and achieve the higher kva rating.

The transformer has a high voltage rating of 13,200 delta volts, and a low voltage rating of 250 delta volts with a full-capacity tap range in 10-volt steps down to 150 volts. The high L.V. line current results from the high kva and the fact that the lowest low voltage tap is at full capacity. The various low voltages are accomplished by means of a motor-operated, remote-controlled tap changer in the H.V. winding.

Pennsylvania now has designed and built furnace transformers ranging from 250 through 25,000 kva, and from 3175 through 82,000 amperes. Why not put this furnace transformer know-how and experience to work for you?

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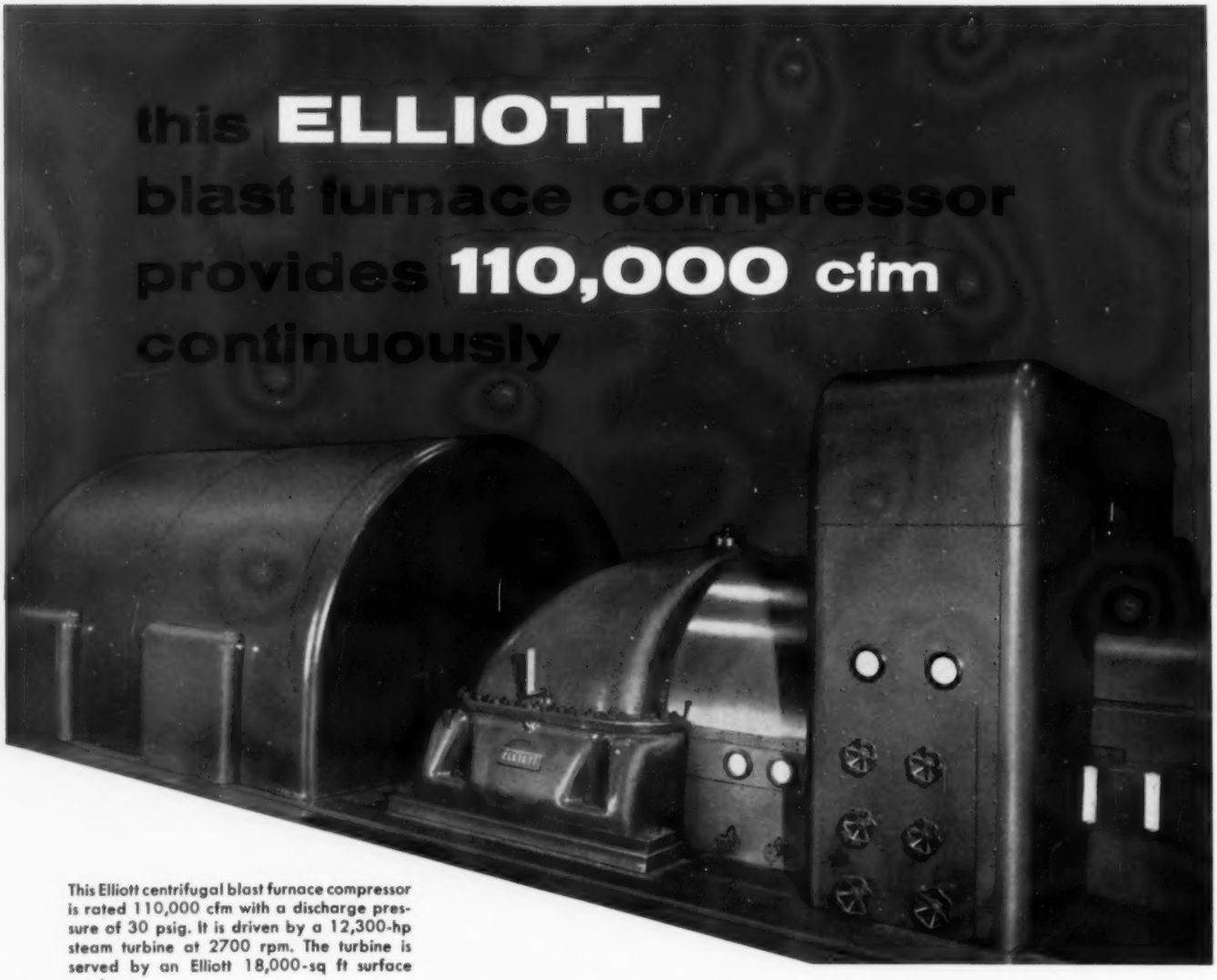
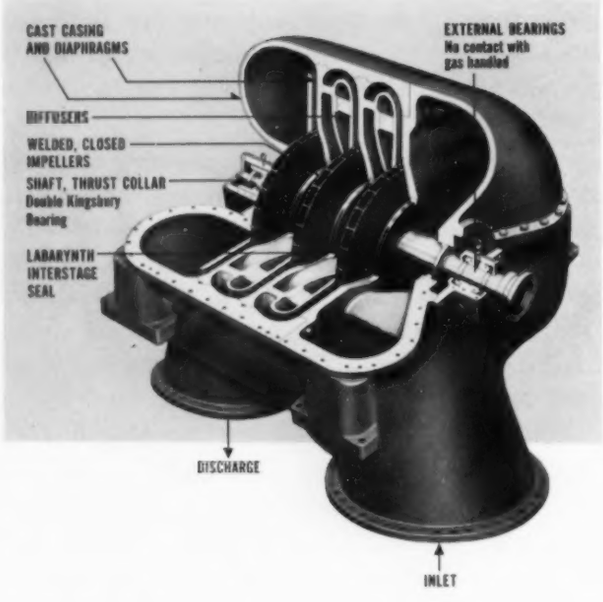


This Elliott centrifugal blast furnace compressor is rated 110,000 cfm with a discharge pressure of 30 psig. It is driven by a 12,300-hp steam turbine at 2700 rpm. The turbine is served by an Elliott 18,000-sq ft surface condenser.

modern design features add up to top, non-stop performance



Talk about air supply for modern blast furnaces and you're talking about compressors which must operate continuously and efficiently—day in and day out—year after year. This is where all Elliott-engineered centrifugal compressors demonstrate their superiority.

The Elliott turbo-compressor-condenser unit shown above serves one of the newest and most modern blast furnace plants. It is driven by a turbine which is a modification of the modern Elliott design used for large turbine-generator units. The neat appearance and ruggedness of the unit is matched by its efficient, dependable operation. Elliott compressors are available in multi-stage types with inlet capacities up to 150,000 cfm.

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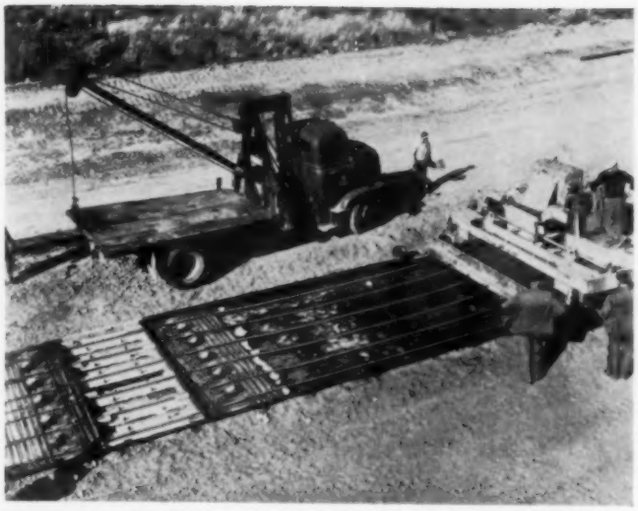

Figure 1 (left)—View of the center of the experimental prestressed concrete roadway built by Jones & Laughlin Steel Corp. in Pittsburgh. Initially, all the concrete was poured except in the gap in the left of the picture. Jacks were placed in the gap and the two end sections were spread apart to a width of eight feet. After this was done, a frame was placed in position to hold the two end sections apart, the jacks were removed, and concrete was placed in the gap. Figure 2 (right)—The control panel for the 10 hydraulic jacks was observed carefully during the jacking operation at Jones & Laughlin Steel Corp.'s experimental prestressed concrete slab site. In the foreground is the compressor for the jacks.

concrete, although only 5 in. thick, is in compression, and therefore it is much stronger right up to the joint.

The joint in the J&L experimental road will have to be wider than the conventional joint because it will have to compensate for the expansion and contraction of 400 feet of concrete, rather than the customary 60 ft.

To find a suitable joint for such a width, the B. F. Goodrich Industrial Products Company has been conducting research, in collaboration with J&L. A prototype of a satisfactory joint has been made. A full-size joint soon will be installed and tested as part of the research on the experimental concrete section.

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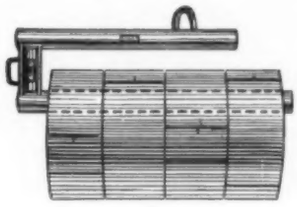

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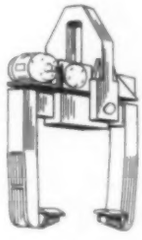
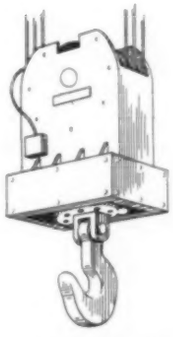


This is a heavy-duty, mill-type Grab for handling coils by means of core entry. It is motor-driven and has telescoping legs which permit minimum space between coils. Its compact design makes it extremely efficient with either high or low ceilings.



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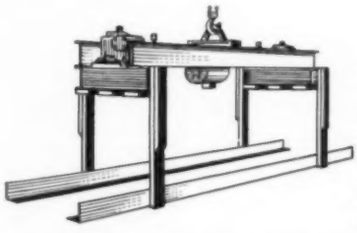

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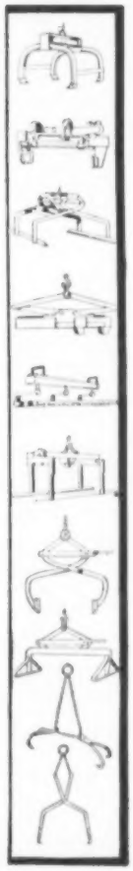

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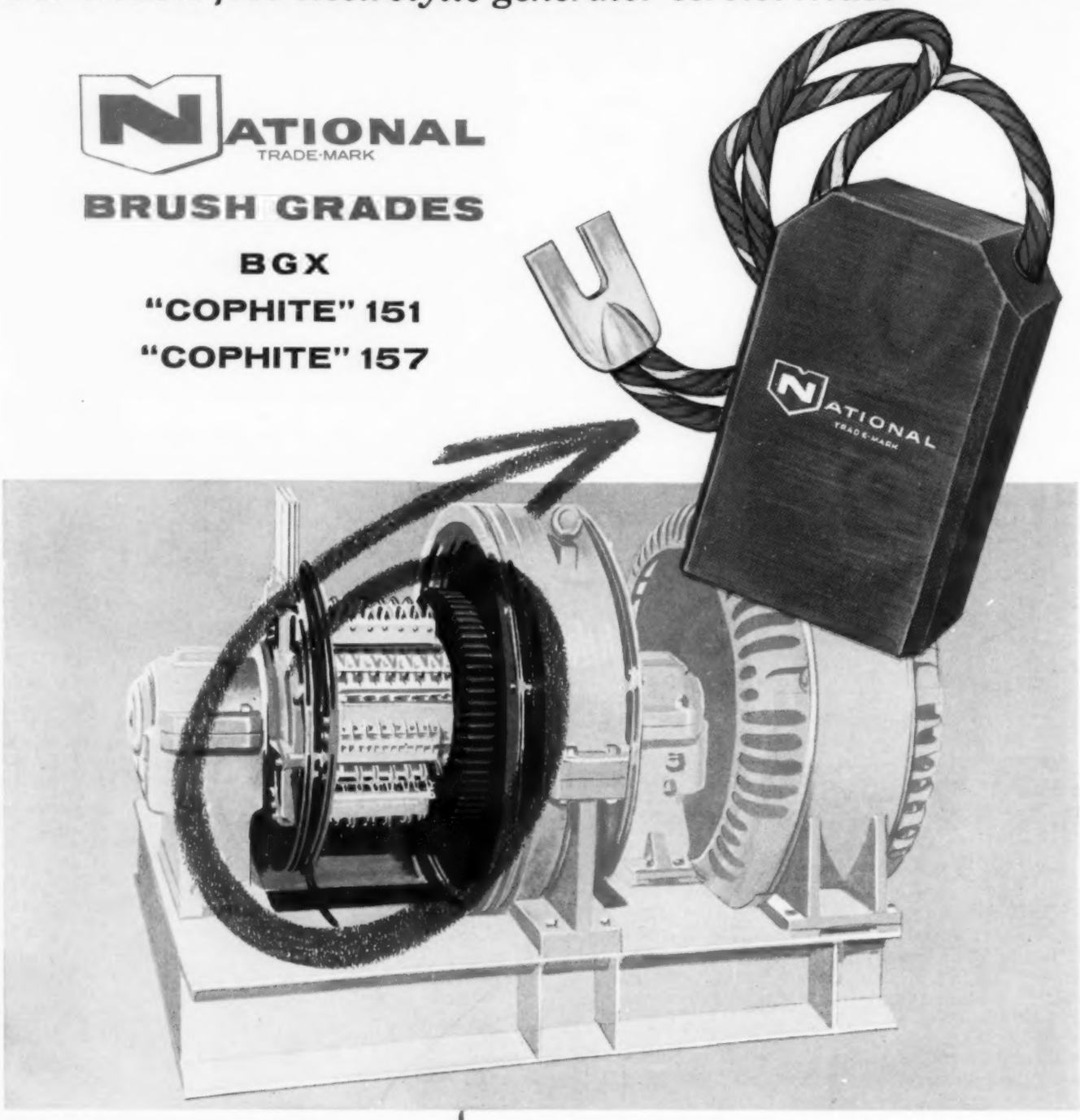

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TACONITE PELLETS—— Problems of Carloading, Stockpiling and Loading Vessels

By

L. O. MILLARD

Assistant General Sales Manager

Link-Belt Co.

Chicago, Ill.

▲ AS the use of agglomerated fine ores has brought economic benefits to the steel industry, so the pelletizing of taconite, jasper, and other low grade iron ores has been a real "shot in the arm" to our domestic iron ore mining industry. The development of new pelletizing processes, and the construction of extensive new facilities, have presented many challenging new problems. Not the least of these have been the handling and transportation of the finished pellets.

When the Erie Mining Company's plant starts operation in the summer of 1957, it will have the highest capacity of any pelletizing plant in the world. It is designed for an annual production of 7,500,000 gross tons, and may be expanded considerably in the future.

Erie will produce finished pellets at Hoyt Lakes, Minnesota, near the ore body. There, the taconite ore will be mined, crushed, ground, concentrated, pelletized, and the pellets will be hardened in shaft type furnaces. From the plant at Hoyt Lakes, the finished pellets will be shipped 73 miles over their own railroad to their new port facility at Taconite Harbor, Minnesota. Entire trains of special bottom dump cars will discharge the pellets into a concrete track hopper above the dock about 1200 feet long, from which they will be withdrawn, weighed and loaded into lake vessels by a unique system of shuttle belt conveyors.

It is planned to operate the Hoyt Lakes' plant twelve months per year, but pellets will be shipped to Taconite Harbor only during the Great Lakes' navigation season—about seven months per year. This seasonal imbalance between the two operations creates the important problem of stockpiling the pellets at Hoyt Lakes during approximately five months of the winter production season.

All of the materials handling requirements of this tremendous enterprise are interesting, and some are most unusual. However, this paper is limited to the handling of finished pellets at only two stages of their transportation from pelletizing plant to lower lakes' steel mills, namely:

1. At Hoyt Lakes—the carloading station or "car pocket" for loading railroad cars during navigation season, which is integrated with the system for stockpiling pellets in the winter.

2. At Taconite Harbor—the facilities for receiving pellets from cars, and for weighing and loading them into lake vessels.

Therefore, this discussion will be confined to the purposes, flow, type of equipment used, and some of the design problems encountered on these two systems.

The pelletizing plant will operate 24 hours per day, and the finished pellets will be conveyed on one of two duplicate belt conveyors to the 800-ton surge bin of the car pocket. These conveyors, and the entire carloading and stockpiling system, are designed for an initial capacity of 1040 gross tons per hr, including surges. Provision is made for a possible future increase to 1870 gross tons per hr. During normal operation, the car pocket is designed to load the 85-gross ton cars on one track at the full capacity of the plant. The pellets are fed from the bins by a double reciprocating feeder and are lowered into the cars by means of a shuttle belt conveyor with hinged loading boom. The rate of loading and the trimming of cars is controlled by an operator from an elevated, enclosed cab between the tracks, as the cars are moved beneath the loading station by locomotive. A second track is available beneath this bin on which the cars may be loaded in an emergency by means of motor operated, undercut gates.

Figure 1—Map shows locations of Erie Mining Company's plants at Hoyt Lakes and facilities at Taconite Harbor.

In case of car delays beyond the surge capacity of the 800-ton bin, the flow of pellets may be diverted to an emergency belt conveyor which conveys them to a temporary stockpile of about 13,000 tons (about 12½ hr). Should the car delay exceed the capacity of this temporary stockpile, the pellets may, of course, be recast by shovel, or the entire flow may be diverted to the winter stockpiling system. Thus, several means are provided to insure continuous plant operation in spite of possible delays from transportation facilities.

During the winter, when rail service to Taconite Harbor is curtailed and plant production must be stockpiled, the car pocket is bypassed. The flow from plant conveyors is routed to the large traveling stacker via the cross conveyor and trailing conveyor. All belts are 42 in. wide, designed for an initial speed of 300 fpm, with provision for a future speed of 525 fpm.

The cross conveyor is simply a stationary belt conveyor with a transfer chute at head end. The trailing conveyor is 1382 ft long and is designed for an ultimate

length of 2890 ft. It is mounted on wheels, and the discharge end is connected to the stacker so that the entire conveyor advances and retreats over its own tracks with the stacker. The housing is arranged so that a section may be removed to clear the transfer chute from the cross conveyor, and it may be easily replaced before the exposed belt passes beyond the transfer house.

The belt conveyor stacker itself is the largest unit of its kind in the United States and probably the world. The conveyor boom structure has a radius of 275 ft, and is mounted on a rotating base carried by eight, fully equalized trucks, each with a hydraulic leveling device. The stacker is designed to bed a pile 90 ft high, 550 ft wide at the top, and about 800 ft wide at the base. It travels at a speed of 10 fpm on a pair of ballasted sectional tracks on 60-ft centers. Normally, in the fall, the tracks will be laid to the far end of the empty storage area, where the stacker will start bedding the pile. As the pile is built up during the winter, the stacker and its trailing conveyor will retreat an average of about 7 ft per day, and the tracks will be removed behind it to facilitate shovel reclaiming in the summer.

The stacker boom will rotate through an arc of 180 degrees at speeds of from 2 to 32 fpm at the outer end. The boom is also hinged vertically so that pellets may be discharged at any elevation from ground level to the top of the 90-ft pile. This feature will reduce the drop of pellets when a new pile is started. It also permits bedding the pile from the bottom to top, which may result in less abrading or spalling off of the pellet surface than when the entire flow is discharged to the crest of the pile. However, this method of bedding will not be used unless it is necessary, as it will require additional movements of the stacker.

During the lake navigation season, the stored pellets will be reclaimed and shipped by rail to Taconite Harbor, while those from the pelletizing plant are being loaded out at the car pocket. Shovels will be used to load them directly into the cars on the siding beside the pile. As successive longitudinal slices are reclaimed from the pile, the tracks will be shifted within range of the shovels.

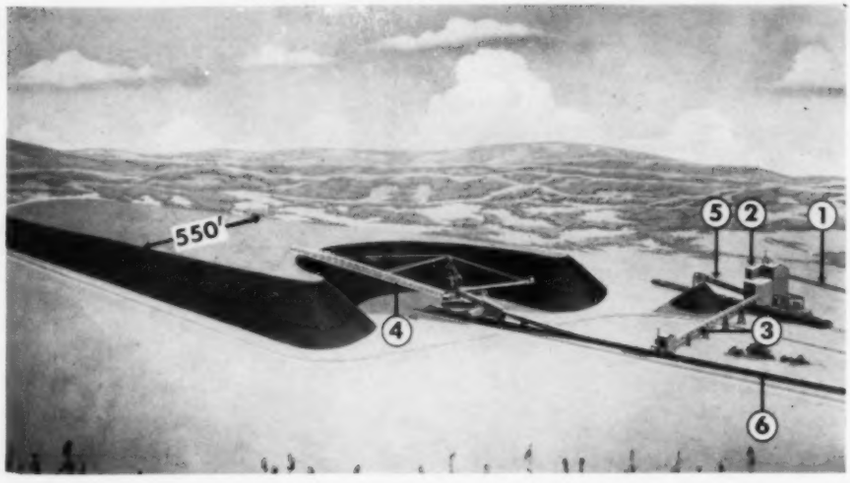

Figure 2—The Hoyt Lakes stockpiling system is used during the winter as shown. During the Great Lakes navigation season, finished pellets from the plant are loaded at the car pocket while stored pellets are reclaimed from pile to cars with shovels. Shown are: (1) plant conveyor, (2) car loading pocket, (3) cross conveyor, (4) belt conveyor stacker of 275-ft radius, (5) emergency conveyor, and (6) trailing conveyor.

This system presented a number of challenging problems and combinations of problems, of which the following stand out as particularly important:

1. The behavior of the pellets on belt conveyors and the maximum angle of inclination for practical operation.

2. The weather, with temperatures of −45 F during the winter operating season, along with blinding snowstorms and high winds.

3. Temperature of pellets, which will be cooled to 250 F on the surface, but whose internal temperatures may, and probably will, exceed this.

4. The dusty condition that may prevail at the transfers.

5. The 24-hr operation, requiring a high degree of dependability of the system and its components, and the need for alternate routes of flow.

Exhaustive tests in 1953 indicated that a cross section of pellets of about 90 per cent of a conventional "B" belt loading could be conveyed up rather steeply inclined belt conveyors without spillage, so long as the feed to the belt continued at a fairly uniform rate. When the feed was interrupted, some of the pellets contained in the last few feet of the bed on the belt "tailed out" or rolled back down the incline. These tail-outs varied with the belt speed, angle and length of inclined portion, but could be limited to a few bushels for each tail-out. Since Erie will operate 24 hr, with a feed that will be continuous except for emergencies, 16 degrees was established as a safe maximum angle for the stacker boom belt conveyor. However, for the safety of personnel, skirts and an expanded metal cover were furnished the full length of this stacker belt in order to confine any large clusters that might roll back and bounce during a tail-out condition.

The climate in the Hoyt Lakes' area is delightful in the summer, but its severity in winter has few equals. The need for operating continuously at −45 F, created unusual problems in the selection of materials and of establishing their limits of design. The 275 ft radius boom and the 90-ft high mast of the stacker required the best possible strength-weight ratio. Axles, wheels, swing pinions and sheaves had to withstand their respective impact loads of traveling, starting and stopping as well as the design loads for a 100-mphr wind. There was no precedent of Izod and Charpy tests for most of the sections required. Those available were sometimes conflicting and, although they served as guideposts, they did not provide reliable design limits.

After considerable investigation, mayari-R steel was selected for cord members of the stacker boom and other highly stressed parts of the boom and mast. Less important

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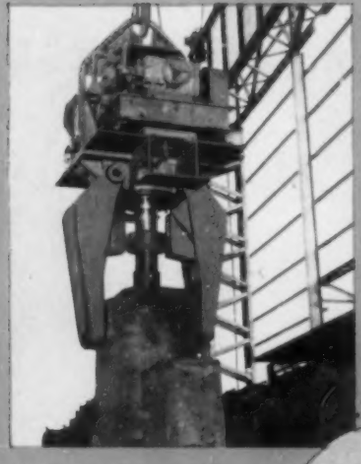

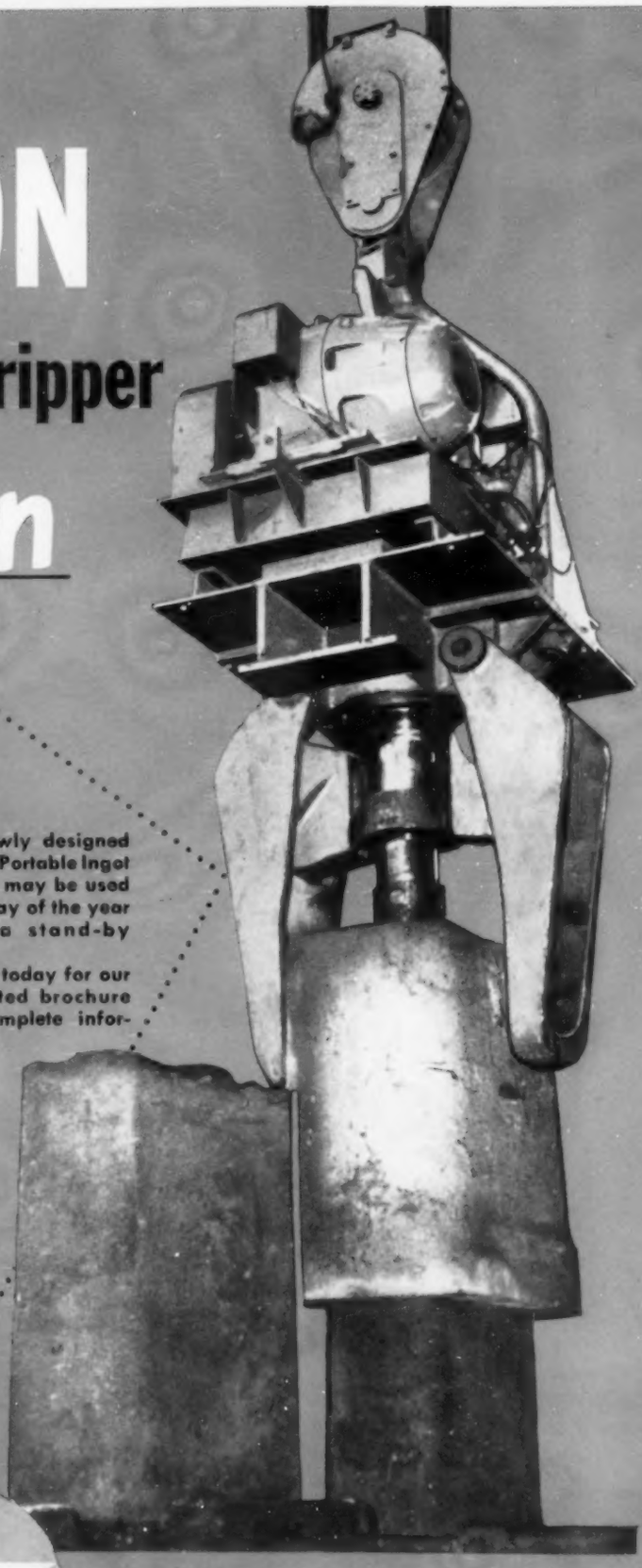

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structural members were made of standard rolled steel with carbon limited to 0.26 per cent. Welding procedures were worked out with special care and a program was set up to magnaflux both in the shop and field. Forgings of an alloy steel for which there was a substantial experience of testing at −40 F, were used for some of the more heavily loaded pinions, wheels and shafts. This is a nickel-chrome-moly steel with some manganese and vanadium, low in phosphorus and sulphur and 0.45 max carbon. Other parts are made of AISI 8735 or AISI 1035, depending upon their loads and importance. Such parts were, of course, heat treated.

The car pocket and all conveyors, including the stacker belt, are enclosed. Heating facilities are provided in all operators' cabs, driving machinery houses, and in the entire emergency conveyor house. It is anticipated that the heat radiated from the pellets will be sufficient for the trailing conveyor hood and other intermediate galleries.

Bearings used throughout the system are of the roller bearing type with cast steel housings. Despite the low temperatures, commercial lubricants are considered satisfactory for the shaft bearings, speed reducers and belt idlers.

Erie's Hoyt Lakes' plant is located practically astride the Laurentian Divide, so high winds are an important consideration in that area. The stacker is designed for stability in a 100-mphr wind with the boom at maximum elevation, but the outer end of boom may be lowered to the pile or ground when desired. All parts are designed for full operation in a 68-mphr wind. However, in the beginning, the anemometer controls will be set to sound a warning at 40 mphr and to actuate a shutdown sequence at 50 mphr. Later, if desired, these controls may be set for higher wind velocities.

Realizing that the crest of the stockpile and the outer end of stacker boom will be obscured from the operator in a heavy snowstorm, special provisions are made for operating "blind." A set of electric probes is suspended from the outer end of the boom, arranged to function in two stages according to the proximity of the pile. At the first stage, they actuate a warning signal to the operators of both the stacker and carloading pocket. At the second stage, when the end of boom is nearer to the pile, the probes actuate a shutdown sequence, which starts the emergency conveyor, diverts the flow to it from the plant conveyors, and stops the stacker, trailing and cross conveyors after a sufficient time interval for emptying them of pellets.

Ordinarily, when running "blind," the stacker operator will rotate the boom a suitable distance after each warning signal, without interrupting the normal flow of pellets over the system. Similar probes have been used for several years by Erie in another application. They have been quite dependable and should be satisfactory for this service. In addition, provision is made for a future wired television setup if it is found desirable.

In order to reduce the possibility of snow drifting against the trailing conveyor like a long snow fence, clearance is provided beneath the housing so the snow can blow through, or the tracks may be plowed clear if necessary.

The temperature of the pellets, themselves, create an ironical contrast to the sub-zero operating atmosphere. It is an understatement to say that there was no precedent for conveyor belts handling material at 250 F that also operated at −45 F. No test work had been done on belt carcasses and rubber compounds for this range of extreme temperatures. With the cooperation of several rubber companies, belts were selected that offer possibilities of reasonably good service. Procedures were set up to clear the system as part of the stopping sequence to protect the belts from prolonged baking action of the pellets if stopped under load.

Due to the heat that will be radiated from the pellets, the car pocket and all belt conveyor galleries are equipped with louvres and powered ventilators, except for the trailing conveyor. A fan is provided to circulate the air through the curved cover of that unit.

A complete dust collection and recovery system is mounted on the stacker to serve the drive house. Filtered air is drawn into the operator's house and the electric control room. The latter is also pressurized. Other operating, drive

Figure 3—(Left) Aerial view of Taconite Harbor. Pellets, received by rail from Hoyt Lakes, are dumped into the 1200-ft long track hopper at dock without cutting the trains, and they are loaded into boats by a system of 25 shuttle belt conveyors. Figure 4—(Right) One of the two operator's houses from which the shuttle belts of boat-loading system are controlled.

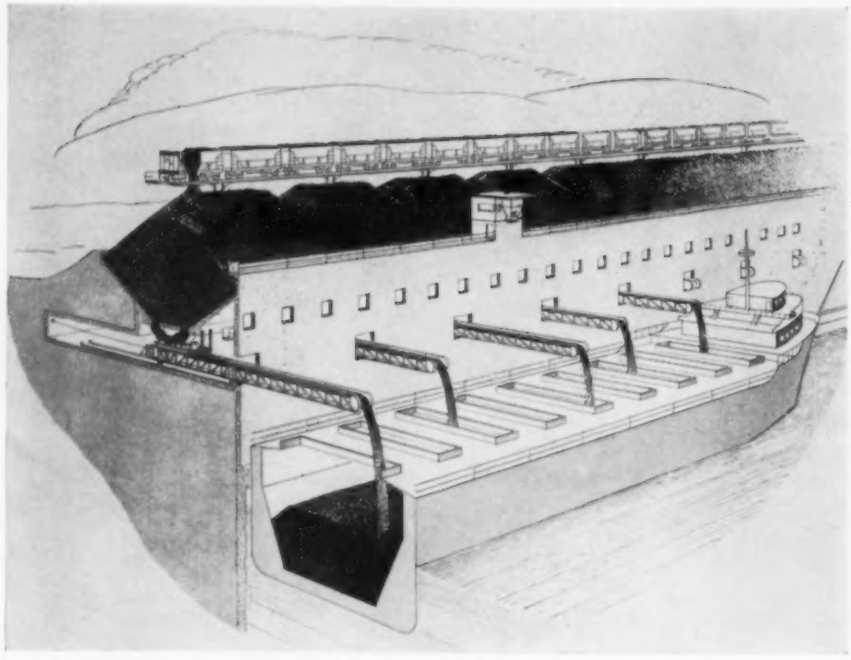


Figure 5—Twenty-five 42-in. wide shuttle belt conveyors with reciprocating feeders and weighing devices, deliver pellets from track hopper to lake vessels. Each unit can load and trim at 750 or 1500 gross tons per hr.

and control houses are similarly equipped, except that dust is exhausted to the outside, but provision is made for future recovery equipment. Dust protection for bearings, lubricants and lubrication procedures were based on Erie's experience in their pilot plant.

Great care has been taken throughout the system to insure continuous operation and to protect personnel and equipment. As mentioned previously, the emergency conveyor serves the most important function of receiving the flow from plant conveyors automatically when any one of a number of conditions at the car pocket or stockpiling system requires its use. In addition, the stacker cab is equipped with devices that provide the operator with information regarding such operating conditions as wind velocity, probe location, the level of rotating frame, centering of belts, turning of belt pulleys, etc., and a bank of fifteen sets of lights and signals serve to warn him of potential trouble. Similar devices in the car pocket control house supply information pertaining to the stacker system, as well as the level of pellets in the bin, the position of diverting gates, and other functions of the car pocket operation.

The major equipment required in the extensive Hoyt Lakes' installation and the principal design problems were, of course, the result of the climate, and the fact that the Great Lakes are closed to navigation during the five coldest months of the year.

At the Taconite Harbor dock, the conditions are quite different. The flow is simple; atmospheric temperatures are moderate, except at the beginning and end of the season; and pellets will be reasonably cool. There, the principal requirements of the system are:

1. To provide surge between rail and water transportation facilities.
2. To load pellets into lake vessels economically at a practical maximum rate.
3. To weigh the pellets during the loading operation.

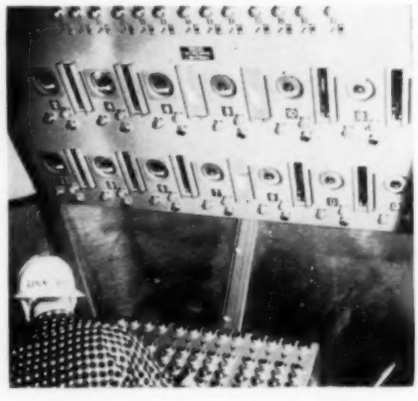
Surge capacity of about 100,000 gross tons will be contained in the track hopper forming part of the dock structure. The initial hopper and dock are 1200 ft long, but they may be extended to 1800 ft in the future. Favorable topography and the rock formation of the shoreline contributed to the practicability and economy of this arrangement. Trains from Hoyt Lakes will be run over the trestle above this hopper, and the pellets will be dumped from special drop bottom cars without cutting the trains.

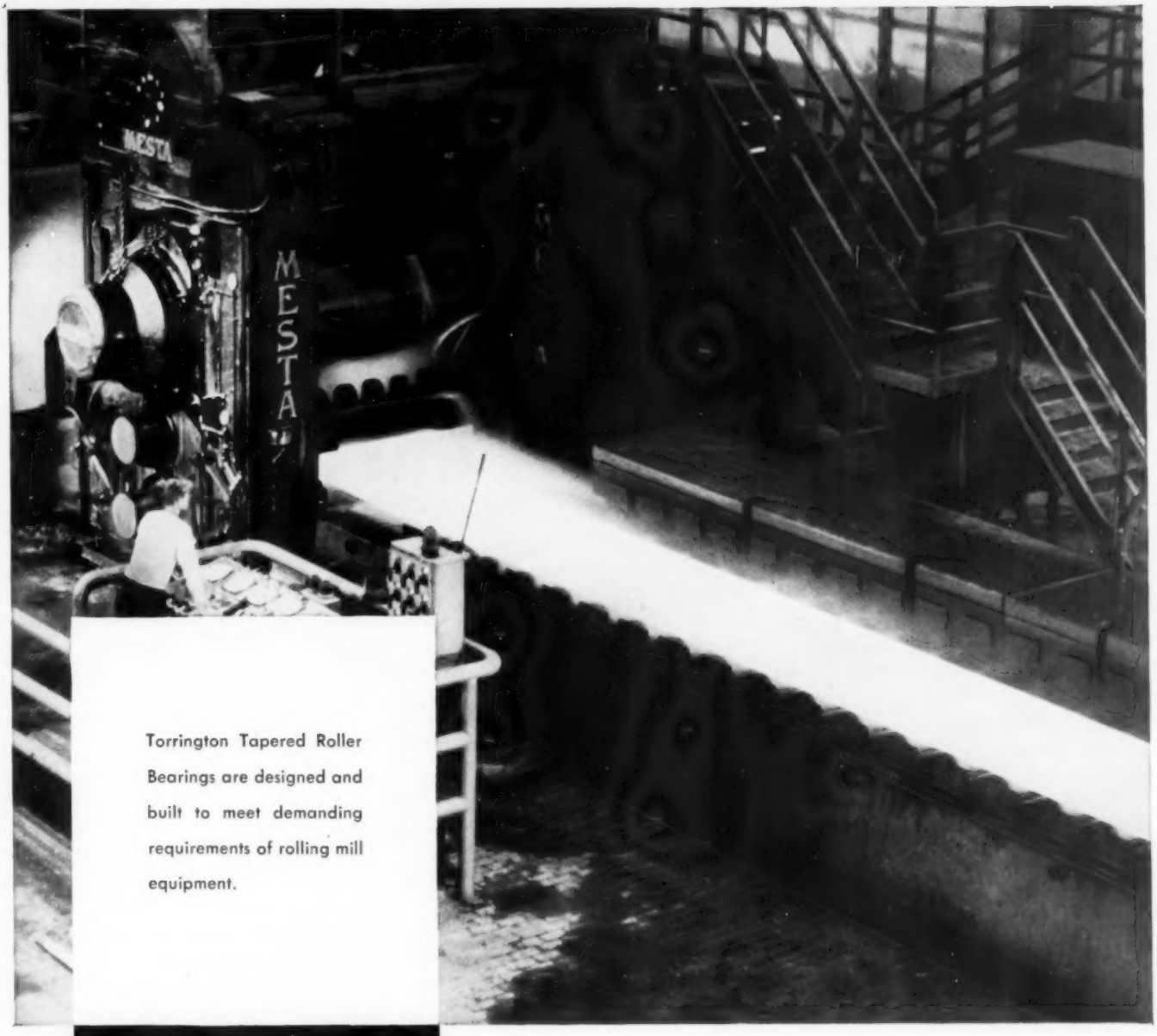
The method of loading boats and the arrangement of the loading system at Taconite Harbor are quite simple, but the magnitude of the operation created problems of control and communication beyond those ordinarily required in plants of this kind. The system consists of twenty-five 42-in. wide shuttle belt conveyors beneath the track hopper spaced at 48 ft centers. Each belt is fed by a double reciprocating feeder at rates of 750 or 1500 gross tons per hr, and is equipped with a weighing device near the outboard end of the boom. Conveyor speeds are 250 and 500 fpm.

The functions of feeding, conveying, advancing, retreating and weighing are controlled separately for each conveyor, but the controls for a bank of twelve conveyors are grouped in one operating cab and, for the other thirteen conveyors, in another cab. It is planned to operate one bank of conveyors for each vessel, so it would be possible for one operator to load and trim up to thirteen hatches simultaneously. There are no boats on the Great Lakes today that would accommodate this many conveyors, but sufficient units were installed to provide flexibility for loading two vessels at once.

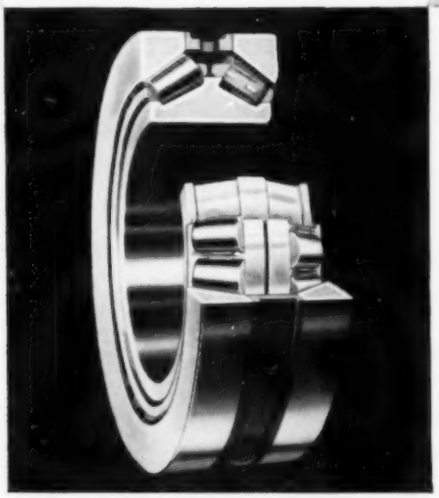
Before we arrive at the oversimplified conclusion that ten or eleven conveyors may start loading simultaneously, let us review some of the practical considerations that limit such a theoretically ideal operation. First, the water ballast must be pumped out of the boat before it can be displaced with cargo. In bad weather this may take

Figure 6—Controls for boat loader are arranged for operating "blind" in bad weather. They indicate for each conveyor the position of flow with respect to hatch opening, the amount loaded, and they will stop each conveyor at a pre-set amount.





Torrington Tapered Roller Bearings are designed and built to meet demanding requirements of rolling mill equipment.



Meeting Production Demands!

Today's heavy production demands on modern continuous hot and cold strip mills put back-up roll thrust bearings to severe test.

That's why you find so many Torrington Two-Row Tapered Roller Bearings in this service throughout the country. Operators have learned that they can rely on Torrington Bearings to roll out record tonnages with only routine maintenance.

Little wonder—steep-angle design gives them capacity to spare for handling heavy thrust loads. Only highest quality electric furnace, alloy-bearing steel is used, carburized and heat-treated for toughness, hardness, stability and uniformity. Precision workmanship assures even load distribution and minimum friction.

Torrington Two-Row Tapered Roller Bearings are available with either pin-type or cast-bronze, land-riding cages. Like Torrington Four-Row Tapered Roller Bearings and Spherical Roller Bearings, they offer performance you can rely on when production schedules demand the best. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

two or three hours. It is also important to consider that the vessel's mate is responsible for the distribution and final location of the cargo in the hold of his boat. He directs where, when, and in what quantities the material will be placed in each hatch. The amount will vary from hatch to hatch and with the season. While the vessel is being loaded, proper trim must be maintained hatch by hatch. Trimming requirements differ widely from boat to boat and from one mate to another. Usually, it is desirable to partially load one or more of the after hatches before proceeding with the others. Neither the mate nor the conveyor system operator could properly observe all of these conditions while loading ten or eleven hatches at once. In bad weather, the boat itself may not even be visible to the operator.

Another obstacle that must be overcome is the justified fear of extremely high speed loading by marine men, who are accustomed to the unrestrained rush of ore into hatches from gravity chutes. It is difficult for many of them to visualize the fact that the stream from each belt will be but little more than a controlled dribble, and that it can be stopped instantly by the conveyor operator. Also difficult to visualize is the fact that each stream will flow uniformly at 12½ or 25 tons per minute to the exact location desired, with virtually no horizontal component of force.

In order to meet these operating conditions, the following basic loading steps have been tentatively established:

1. Initial flow to all hatches will be directed to the centerline of the boat, with due regard for keeping the vessel on an even keel.

2. A predetermined tonnage will be delivered to each hatch in an amount that will be less than that finally required, and the flow will be shut off automatically when such an amount is reached.

3. A predetermined sequence will be set up for loading each vessel hatch by hatch, and, approximately, ton by ton. For example, assume the belt to the after hatch is started first, and after delivering, say, 300 tons, the next belt starts loading its hatch while the first one continues. As the flow is started from successive belts or groups of belts, the previous units continue loading until all belts that can be accommodated by the boat are operating simultaneously.

4. The peaked piles in the various holds will be trimmed or leveled off by adding pellets on both sides of the peaks.

5. If desired, the boat will then be shifted along the dock one hatch length (24 ft) so that the intermediate hatches may be loaded and trimmed as required.

Because of the number and variation of simultaneous operations of the conveyor system, controls were worked out with unusual care to provide ease of operation, automatic operation where possible, and to safeguard personnel, equipment, and operational sequences. Each of the two operating cabs is equipped with a console and two control panels, with their instruments arranged in sets and numbered by conveyors. The small console (practically in the operator's lap) contains instruments necessary to control and indicate all functions of the belt conveyors and the movements of the shuttles. It also includes lights which signal the operator when each hatch has received its predetermined tonnage. Above, and in front of the operator, another panel contains the conveyor enclosure door switches and a set of bar indicators that, at all times, show him the position of the stream from each belt with respect to the center and edges of the hatch. A set of dials indicates the accumulated tonnage of pellets in each hatch with respect to the preset tonnage. Behind him, a third panel contains totalizing and recording devices for each hatch. A microphone is suspended above him for communication with mate.

The use of these controls can best be illustrated by following through the operator's duties during a typical loading cycle:

1. Attaches appropriate masking clips to the bar indicators. These masking clips are calibrated to the hatch width, centerline, and distance from the dock face. A set for each vessel will be kept in both operating cabs.

2. Presets scale totalizing dials for automatic cutoff of predetermined amounts in the various hatches.

3. Opens all necessary doors of shuttle enclosures.

4. Positions required number of shuttle belts so they will discharge to centerline of boat, or as otherwise directed by vessel's mate.

5. Starts initial shuttle belt or belts and their feeders, as previously agreed or as directed by mate. The feeders are automatically prevented from starting until the shuttles advance beyond the edge of hatch.

6. Continues loading operations by starting other belts and feeders in the previously agreed sequence, or as directed by mate.

7. Positions belts for trimming, and adjusts capacity while flow from them continues, as required.

8. Stops each feeder and empties the belt after each hatch is loaded to the satisfaction of the mate.

9. Stands by while boat is being shifted into position for loading the intermediate hatches, after which the cycle is repeated.

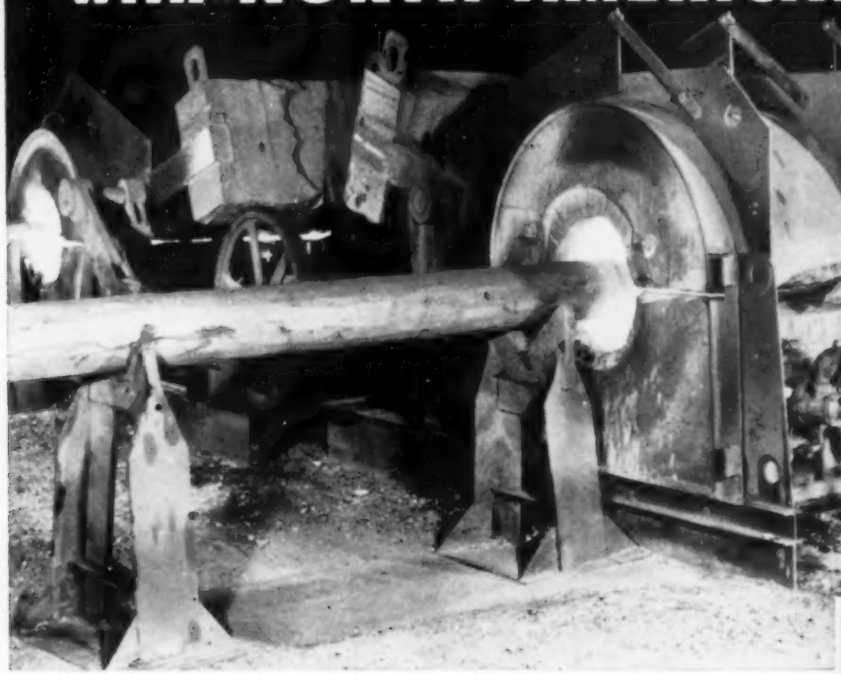
10. Maneuvers the flow from the various belts for any special trimming that may be required.

11. Clears and stops all conveyors, retracts them into the wells and closes all doors when vessel is completely loaded and trimmed.

12. Records, by means of a ticket recording device, the tonnages delivered by each conveyor to its respective hatch.

Experience with other conveyor type docks indicates that the maximum potential of such loading systems can be obtained only from experience, co-operation and confidence. Some of the operator's duties at Erie can *now* be performed before the boat arrives or while it is being docked. Delays can be reduced still further when he is permitted to perform other pre-loading duties, which will be made possible as more predetermined hatch tonnages and sequences are developed. Higher loading rates will be achieved as he is allowed to preset his controls for initial tonnages that are nearer to the final amounts. Simultaneous, high capacity trimming of some or all of the hatches can only be accomplished after marine men are assured that it will not endanger their boats. It will take several trips by each boat to reach the high loading capacity of which this unique system is capable.

Huge Crankshafts
GET HOT IN A HURRY
with NORTH AMERICAN Burners



High speed heating, such as usually applied to small parts in mass production, is used by **Erie Forge & Steel Corporation** for heating huge locomotive crankshafts for die press forging . . . convincing evidence of the efficiency of North American Burners and Blowers.

Amazingly, **#6 oil** is used to fire these compact barrel-type furnaces. North American Blowers and Series 212 Burners provide thorough atomization for fast heat release.

8⅞" billets are heated from 1100 F to 2350 F in a day-long **average** time of 36.9 minutes. The result—superior quality metal. Average oil consumption is 32 gallons per ton of steel. It will pay you to look into the results you can expect by installing North American for high speed heat release.

Large photo shows 8⅞" billets in 2 of 8 small (36" I.D.) furnaces. Note Burners in right foreground.

Small photo is a close-up view showing burner tiles and flames whipping around a partially forged 10" crankshaft in a large furnace.

For detailed engineering information, consult your nearby North American combustion specialist. For equipment information, write for bulletin.

NORTH AMERICAN COMBUSTION Since 1917

The **NORTH AMERICAN** Manufacturing Co.

Combustion Engineers

Cleveland 5, Ohio

"On a low voltage situation, Fusetron dual-element Fuses opened and warned us of the need for a larger transformer"

HERMAN BOND, PRES.
ACME ELECTRIC CO., DENVER, COLO.

Here's Mr. Bond's own story of how Fusetron fuses helped solve the low voltage situation.

"A flock of Fusetron dual-element fuses blew one afternoon at the Duffy Bottling Works several weeks after we had completed changing the entire plant to this type of fuse in an effort to eliminate extreme heating in switches and to get more dependable protection.

"Before putting the circuits back in operation we wanted to find out what had caused the Fusetron fuses to open.

"On checking, we learned that a severe voltage drop occurred whenever the plant was in full operation. The trouble was due to the transformer being too small to keep the voltage at its normal value of 220 volts.

"To prevent the trouble recurring, a larger transformer was installed. Since then, they have had no more low voltage difficulty.

"By opening and warning of the need for a larger transformer, Fusetron fuses not only saved Duffy Bottling Works the expense of possible motor burnout, but also prevented costly slowdowns in their production."

You too, can save money throughout the plant by using Fusetron fuses . . . ***They Provide 10 Point Protection*** ***1.*** High interrupting capacity —protect against short circuits. Have proven on tests to open safely on circuits set to deliver in excess of 100,000 amperes. ***2.*** Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation. ***3.*** Protect against needless blows caused by harmless overloads. ***4.*** Provide thermal protection—for panels and switches against damage from heating due to poor contact. ***5.*** Protect against waste of space and money—permit use of proper size switches and panels. ***6.*** Protect motors against burnout from overloads. ***7.*** Give DOUBLE burnout protection to large motors—without extra cost. ***8.*** Protect motors against burnout due to single phasing. ***9.*** Make protection of small motors simple and inexpensive. ***10.*** Protect coils, transformers and solenoids against burnout.

DON'T RISK LOSSES! One lost motor . . . one needless shutdown . . . one destroyed switch or panel . . . one burned out solenoid . . . may cost you far more than replacing every ordinary fuse with Fusetron dual-element Fuses. *Write for Bulletin FIS.*

FOR LOADS ABOVE 600 AMPS.—USE BUSS HI-CAP FUSES to coordinate your electrical circuits.

On 600 volts or less, BUSS Hi-Cap fuses have an interrupting capacity sufficient to handle any fault current regardless of system growth.

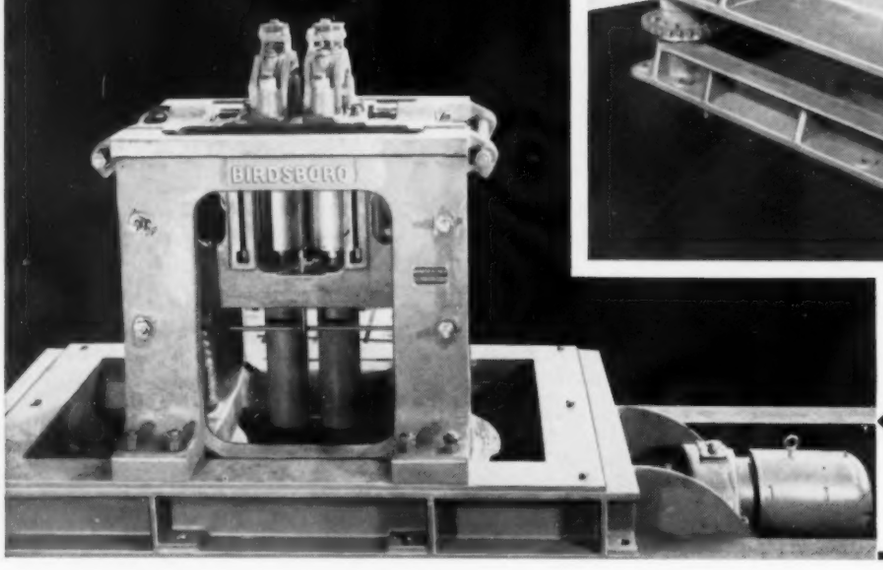
They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuits of origin. Write for Bulletin HCS.

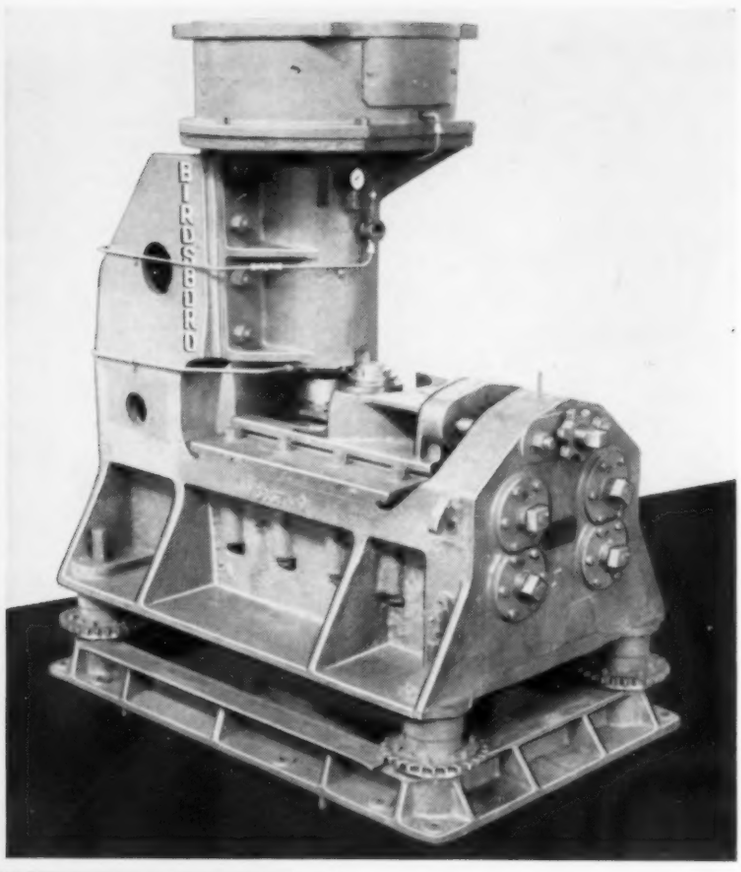
BUSSMANN MFG. CO. *(Div. of McGraw-Edison Co.)*
University at Jefferson, St. Louis 7, Mo.

Play Safe! install FUSETRON dual-element FUSES and BUSS Hi-Cap FUSES throughout entire Electrical System!

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

design versatility...





▲ VERTICAL MILL with twin motor drive, one motor above the other. Rolls are short sleeves.

◀ VERTICAL MILL with full length roll bodies driven by universal spindles from below. Pinion stand and bevel gear drive are located below the mill.

Design Versatility—BIRDSBORO's Key to New Gains in Mill Productivity for You

It takes job-designed equipment to make the production increases needed by every mill operator today. It's not enough to replace or build new machinery, but each piece must be perfectly designed to supply the full potential of the mill. The industry-wide scope of the Birdsboro staff provides versatility of design ideas that result in "customized" work. The examples pictured show two vertical mills of different design. Each is specifically designed for its application. Your Birdsboro representative can tell you about the special advantages of these and many other special pieces of equipment. Main office and plant: Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa., District Office: Pittsburgh, Pa., Subsidiary: Engineering Supervision Co., 120 W. 42nd St., New York 36, N.Y.

MM60-57

BIRDSBORO
STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES (Metalworking and Extrusion) • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

New Glass Material May Offer Competition in Some Metal Uses

▲ A new world of materials for a new world of products appears on the horizon with the announcement by Corning Glass Works of Pyroceram. This is a new *crystalline* material made from glass which is tough, heat resistant, harder than steel and lighter than aluminum. Its first application will be in radomes which are nose cones for guided missiles, a use which demands most stringent service properties.

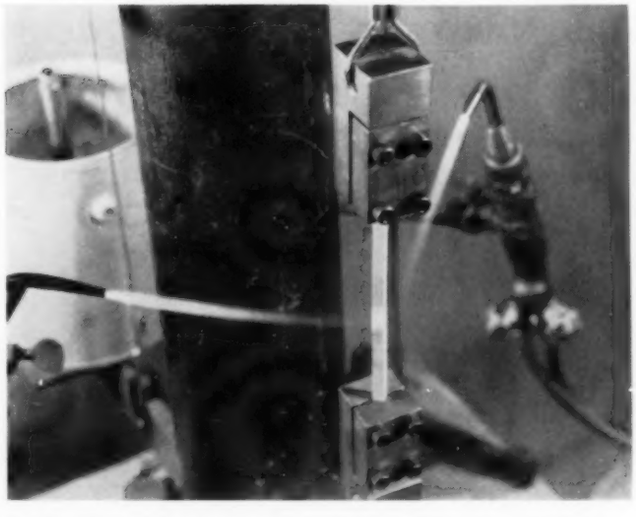
Pyroceram can be formulated into many materials with excellent mechanical strength, good electrical properties and good thermal shock resistance and hardness. One of the factors which give it good shock resistance is that the expansion coefficients can be varied from a negative value up to about 0.0000002 per degree C. This low coefficient reduces the thermal stresses and strains which have such a bad effect on brittle materials.

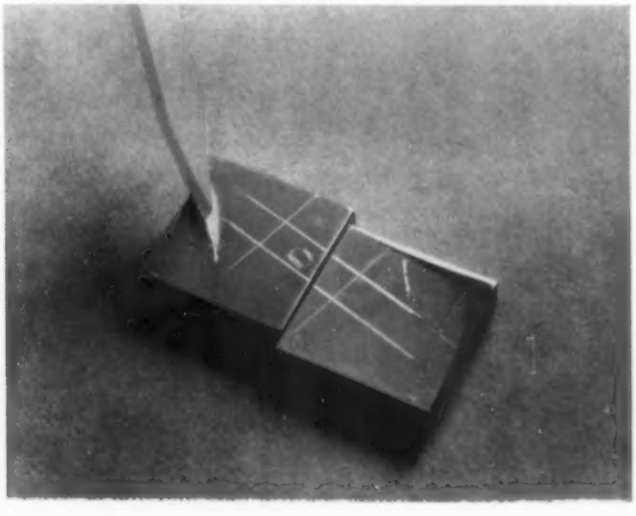
The material is essentially a crystalline material which is formed from a noncrystalline glass. In the process, the glass batch is melted after nucleating agents are added. After melting subsequent heat treatments cause the nucleating agents to form sub-microscopic crystallites, each of which acts as a center of crystal growth as the heat treatment continues. More than 400 types of this material have been experimentally melted. Little experience is, however, yet available on which conclusions can be reached as to future applications. Costs are more than glass and less than stainless, which roughly means that the material will cost from 30¢ a pound up depending on type, finish, shape, quantity and so forth.

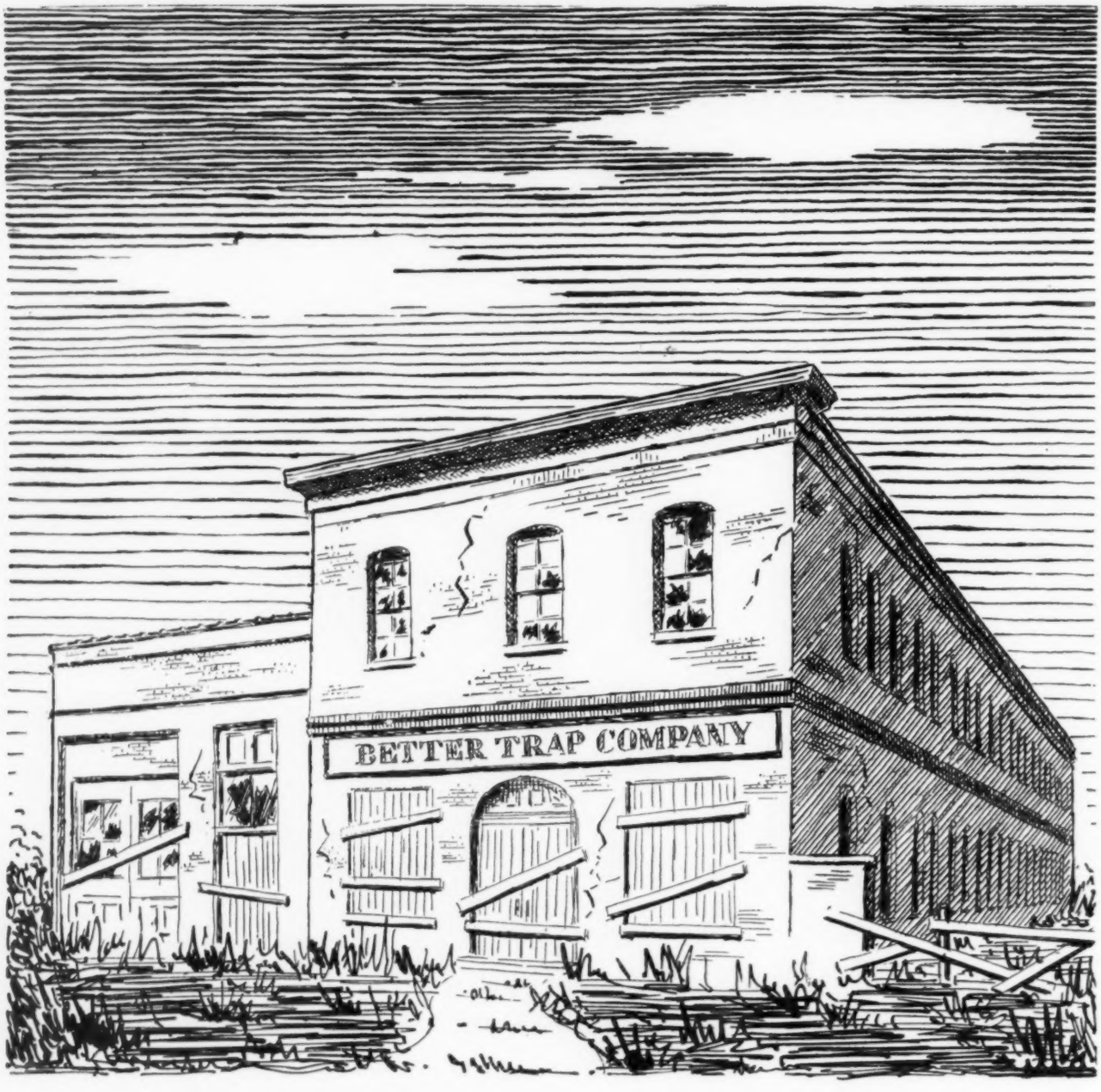
The material has a high strength-weight ratio. Although lighter than aluminum, it is stiffer since its modulus of elasticity is about 19,800,000 psi. Its modulus of rupture runs from 32,000 psi up.

One of the most important characteristics is that the material can be formed very easily into almost any shape while in the glassy state by the usual glass forming techniques such as blowing, pressing, drawing, casting and so forth. The end product is a fine grain crystalline material which is nonporous and harder than most ceramics and many metals. It differs from ceramics which have large crystals, and it has an advantage over ceramics in its ease of formability. It is also resistant to corrosion by many chemicals.

Figure 1 (left) — Even under the heat of two acetylene torches and with weights pulling at each end, this rod of pyroceram maintains its strength indefinitely. Flexural strengths as high as 80,000 psi have been measured on certain pyroceram materials; one pyroceram commonly used has a flexural strength of 37,000 psi. Figure 2 (right) — Harder than steel or brass, pyroceram can easily score both materials in a scratch test. It can be made harder than flint or granite by controlling sub-microscopic size of crystallites in the glass.







MOUSETRAP, STEAM TRAP, SEWER TRAP

...it makes no difference

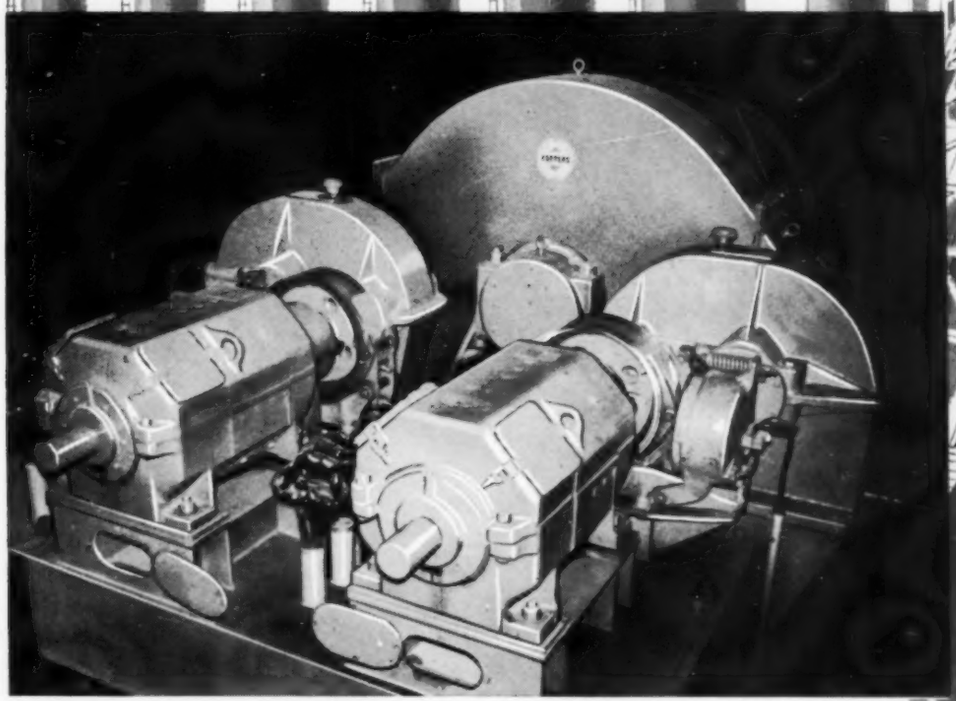
. . . the world *won't* beat a path to the door of the man who builds a better one *and then doesn't advertise it* so that people will know about his product, know where it can be bought and how much it costs.

Advertising benefits the buyer, too. It tells you the product story, makes it easy for you to buy. Even more important to you, advertising leads to mass production and volume sales . . . which means lower costs and lower prices.

Yes, "Advertising Benefits You" . . . 'specially business-paper advertising.

IRON AND STEEL ENGINEER

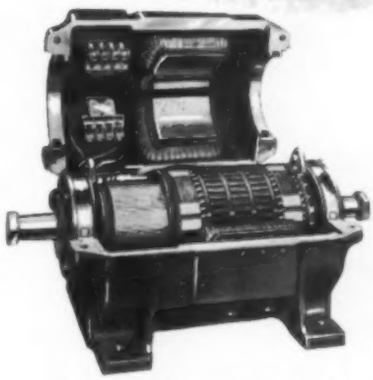
Giving a lift to steel mill skip hoists . . .



Two Elliott Crocker-Wheeler 600 Series Mill Motors driving a skip hoist in a mid-Western steel mill

ELLIOTT C-W MILL MOTORS

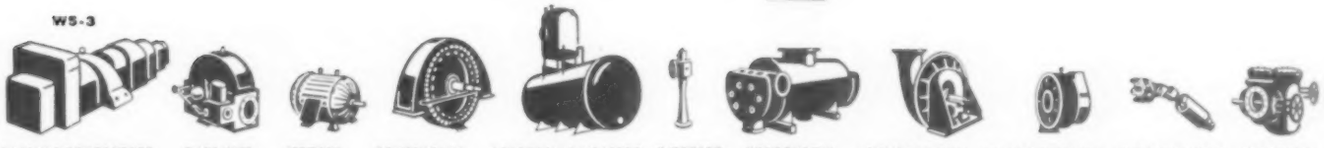
These dependable motors are naturals under rugged, heavy duty operations. They stand up to punishing overloads, constant starting and stopping, reversing strains, etc., and come back for more every time. Their compact durability plus advanced engineering features assure greater power per standard frame size. The tough cast-steel frame is split for easy access to armature, bearings, and field coils. Standard 600 series motors can be readily adapted to separately forced-ventilated, protected self-ventilated or built-in back gear types. For details, ask your local Elliott field engineer, or write for the Mill Motor Bulletin. Address Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.



The split frame is hinged for easy access to all motor parts.

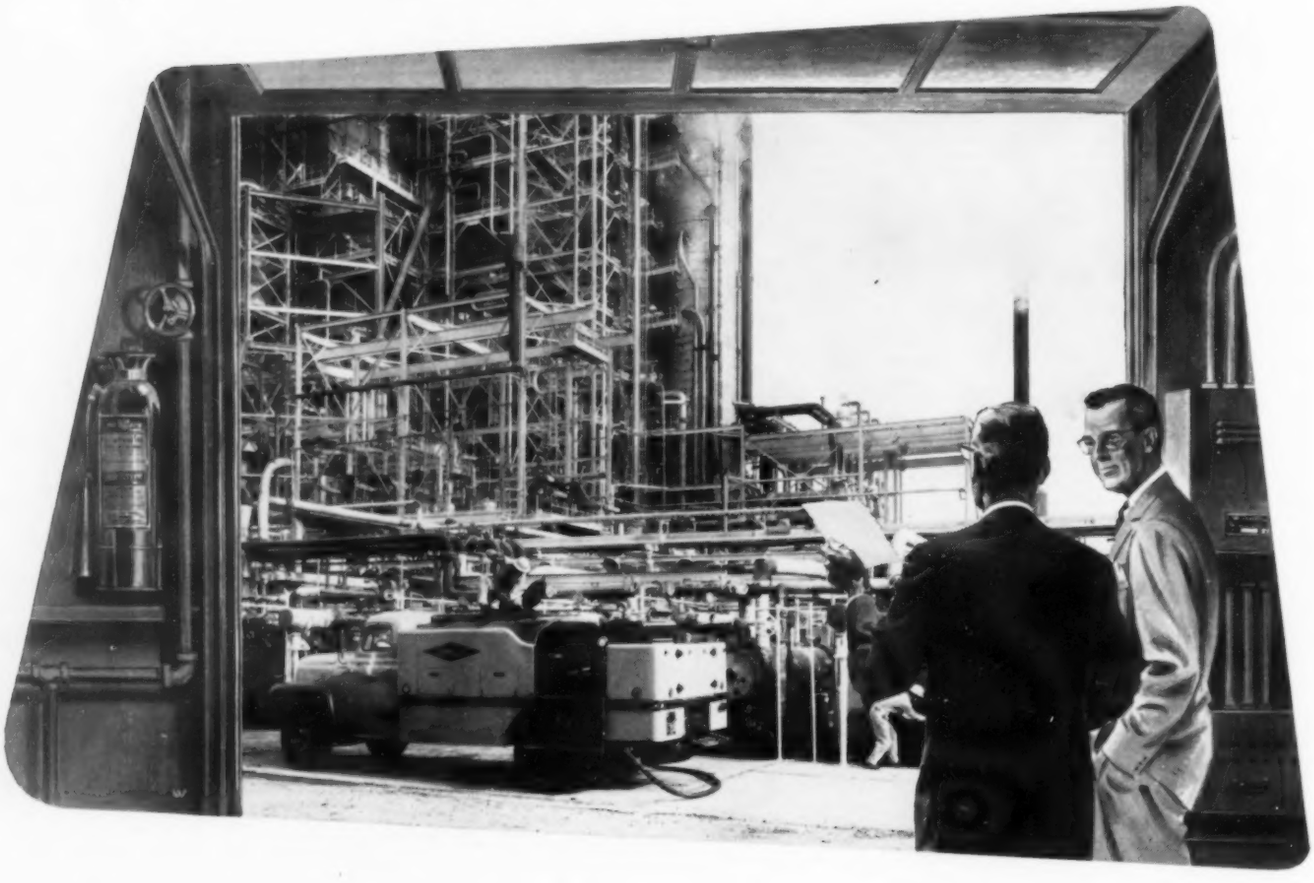
ELLIOTT Company

WS-3



TURBINE-GENERATORS TURBINES MOTORS GENERATORS DEAERATING HEATERS EJECTORS CONDENSERS COMPRESSORS TURBOCHARGERS TUBE CLEANERS STRAINERS

Dowell Service Helped This Plant Profit By Saving $312,700 in Maintenance Costs!



To clean and service the giant catalytic crackers in today's modern refineries is quite a job . . . and very costly. Costly, that is, unless Dowell Service is on the job to help clean the "cats"—chemically. Here's an example of how Dowell chemical cleaning service cut turnaround costs for one refiner by $312,700.

Dowell was called in to provide cat cracker turnaround service which included the cleaning of: two flue gas coolers, two catalyst coolers, four overhead aftercoolers, one light gas oil cooler, one heavy gas oil cooler, two top tray reflux coolers, and two final gas condensers.

Dowell's time: thirteen and one-half hours; Cost: $2300.

It is estimated that this same cat cracker service, if done by mechanical methods, would have cost the refinery: 1) Additional downtime of seven days—$210,000; 2) Additional spare bundle inventory—$100,000; 3) Labor—$5,000.

The refinery enjoyed a $312,700 operating credit from this single cat cracker turnaround—not including expected efficiency increases.

Dowell provides expert service in removing scale and sludge from product, process and steam generating systems. Dowell does the job for you—furnishing all chemical solvents, trained personnel, pumping and control equipment. Furthermore, Dowell has the experience in chemical cleaning to provide assurance of a job well done.

While the example here deals with an oil refinery, Dowell chemical cleaning has recorded similar profit-making savings for other industries. Dowell engineers can show you performance data in almost any field — steel, chemical, power, paper, construction.

For specific information on how Dowell chemical cleaning can help your plant to greater profits, call the Dowell office nearest you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically

DOWELL

A SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

May 2

▲ According to the Bureau of Mines, U. S. Dept. of the Interior, U. S. iron mines produced 3,840,977 gross tons and shipped 1,900,885 tons of iron ore during January, 1957. Mine stocks at the end of January totaled 7,649,479 gross tons. Imports of iron ore in January amounted to 1,691,591 gross tons; exports of iron ore totaled 83,547 gross tons.

▲ Edison Electric Institute reported that electric power use last week totaled 11,300,000,000 kwhr, lowest since last Xmas.

May 6

▲ Stockholders of Barium Steel Corp. approved distribution of Republic Industrial Corp. shares in ratio of one share of Republic for each three shares of Barium Steel Corp., and also approved increase in Barium Steel's authorized common capitalization to 10,000,000 shares.

▲ The AISI reports that the operating rate of the steel industry for the week of May 6 is scheduled at 87.5 per cent of capacity. This is equivalent to 2,240,000 tons compared with 2,226,000 tons one week ago and 2,343,000 tons one year ago. Index of production for the week is 139.4.

May 7

▲ The AISI reported that the iron and steel industry's estimated payroll for March, 1957, was $344,185,000, compared with $327,510,000 for February, 1957, and $338,140,000 in March, 1956; the total for the first quarter of 1957 is estimated $1,032,375,000, compared with $984,260,000 for the same period in 1956. Average hourly payroll cost of wage earners in March was $2,834 (plus $0.29 for fringes) against $2,852 during February and $2,604 during March, 1956. Total employment was estimated at 671,100 during March, against 677,100 in February; average hours worked during March, 1957, equaled 38.7 hr compared with 39.8 hr in February, 1957, and 40.7 hr in March, 1956.

▲ Roger M. Blough, chairman of U. S. Steel Corp., at the annual stockholders meeting, stated that the steel industry will have to increase its annual capacity 50,000,000 tons by 1975 to meet indicated demand, and that U. S. Steel would have to boost its capacity 1,000,000 tons each year to maintain its relative position in the market.

▲ Price of zinc was reduced 1½¢ to 12¢ in East St. Louis, reflecting the first change in the market since early January.

May 8

▲ Commerce and Labor Depts. reported that rising construction costs helped push building outlays for the first quarter of 1957 to $12,500,000,000, or 2 per cent over the same period in 1956.

▲ Lake Superior Iron Ore Assn. reported that shipments of iron ore down the Great Lakes for the week ending May 6 totaled 2,647,880 gross tons, compared with 2,662,720 tons shipped during the corresponding week in 1956.

May 9

▲ Commerce Dept. reported that business inventories in March, on a seasonally adjusted basis, rose only $100,000,000 over February, 1957, the smallest gain since January, 1955.

▲ Frank R. Palmer, president of Carpenter Steel Co., reported negotiations are underway with trustees of Northeastern Steel Corp. for Carpenter's acquisition of control of Northeastern.

▲ Bureau of Census, U. S. Dept. of Commerce, reported that shipments of iron and steel castings in 1956 totaled 16,744,000 short tons, or four per cent below 1955.

May 10

▲ Lead was reduced ½¢ per lb to 15½¢ in New York, and custom smelters reduced price for copper ½¢ to 30¢ per lb, widening the spread between the custom price and the 32¢ charge of major U. S. copper producers.

▲ H. H. Robertson Co. acquired Porcelain Steel Corp. Connorsville, Ind.

▲ According to the AISI, steelmaking furnaces produced 9,814,000 net tons of ingots and steel for castings in April, compared with 10,589,074 tons during March, 1956, and 10,523,785 tons in April, 1956. Total for the first four months of 1957 reached 41,399,042 net tons compared with 42,395,799 tons for the same period in 1956.

May 13

▲ The AISI reports that the operating rate of the steel industry for the week of May 13 is scheduled at 87.9 per cent of capacity. This is equivalent to 2,251,000 tons compared with 2,220,000 tons one week ago and 2,345,000 tons one year ago. Index of production for the week is 140.1.

May 14

▲ Price of zinc in East St. Louis dropped an additional ½¢ to 11½¢ per lb.

▲ Interlake Iron Corp. reported sales of $30,036,458, earnings of $1,725,987 equivalent to $0.77 per share for the first quarter of 1957, compared with sales of $25,587,409, earnings $1,752,160 or $0.90 per share for the first quarter of 1956.

May 15

▲ Commerce Dept. reported that the national production of goods and services for the first quarter of 1957, ran at an annual rate of $427,100,000,000 compared with an annual rate of $403,400,000,000 for the first quarter of 1956.

▲ Lake Superior Iron Ore Assn. reported that shipments of iron ore down the Great Lakes for the week ending May 13, totaled 2,994,458 gross tons, compared with 2,968,294 gross tons for the same week in 1956.

May 16

▲ The Commerce Dept. reported that personal income for April, 1957, was at an annual rate of $339,300,000,000, $1,200,000,000,000 higher than March, 1957; and nearly $18,000,000,000 over the yearly pace in April, 1956.

▲ The AISI reported that shipments of finished steel products for construction purposes (including maintenance) for March, 1957, reached 1,120,545 net tons; shipments of heavy structural shapes in March totaled 614,277 net tons.

May 17

▲ Price of lead was off ½¢, to 15¢ per lb in New York, the second such decline in a week.

▲ ARCI reports that deliveries of new domestic freight cars in April, 1957, totaled 8961 compared with 9772 in March, 1957, and 5943 in April, 1956. Orders

totaled 6429 cars in April, 1957 compared with 5359 cars in March, 1957 and 6559 in April, 1956. Backlog of cars on order on May 1 totaled 105,190 compared with 107,708 on April 1.

▲ The Bureau of Mines reports that the consumption of scrap during, March, 1957 totaled 6,284,000 gross tons and pig iron 6,153,000 gross tons compared with 6,038,436 tons of scrap and 5,860,099 tons of pig iron in February.

May 20

▲ The AISI reports that the operating rate of the steel industry for the week of May 20 is scheduled at 86.7 per cent of capacity. This is equivalent to 2,220,000 tons compared with 2,155,000 tons one week ago and 2,396,000 tons one year ago. Index of production for the week is 138.2.

▲ New car stocks with auto dealers are estimated around 800,000 cars, approximately a 40-day supply at current sales rates, and 100,000 cars less than a year ago.

May 21

▲ The Aluminum Assn. reports primary aluminum production in the United States during April, 1957 was 138,728 short tons compared with 135,706 short tons in March, 1957 and 144,727 short tons in April, 1956.

▲ Commerce Secretary Weeks told Congress when called before the House Small Business Committee that he thinks future voluntary agreements to reduce steel scrap exports will replace recently imposed shipment limits and avoid the need for permanent quotas.

▲ Republic Steel Corp. predicted, in a new book "USA—Tomorrow," that the nation's production of goods and services may reach $560,000,000,000 or more by 1965, compared with $412,000,000,000 in 1956. To reach this figure necessitates that business spending for new plant and equipment be increased to $50,000,000,000 annually by 1965, from $35,000,000,000 in 1956.

May 21

▲ The Bureau of Mines reported that imports of iron ore in February, 1957 totaled 1,357,425 gross tons valued at an average of $8.40 per ton, or $11,399,543. In February, 1957 iron ore mine production in the United States amounted to 3,560,384 gross tons, shipments, 1,817,081 gross tons, and total mine stocks on February 28, 1957 were 9,397,846 gross tons. Exports of iron ore in February, 1957 totaled 93,712 gross tons.

May 23

▲ The Industrial Heating Equipment Assn. reported that orders for industrial furnaces during April, 1957 amounted to $3,164,000, compared with $8,803,000 for April, 1956.

▲ Electric power output last week topped 11,500,000,000 kwhr, a gain of 208,000,000 kwhr over the prior week, and 5.9 per cent over the year-earlier-level.

▲ Machine tool makers orders in April, 1957 totaled $51,300,000, down 12 per cent from March, 1957 and down 35 per cent from April, 1956; shipments in April just about equaled the March, 1957 shipments.

▲ Exports of licensed non-strategic goods to Russia and her east European satellites for the first quarter of 1957 totaled $16,400,000, compared with $6,400,000 for the last quarter of 1956, and $8,600,000 for the first quarter of 1956.

▲ Acme Steel Co. plans to raise $33,000,000, from a new bond issue and sales of additional common stock to shareholders. Each shareholder of record May 21 will receive rights to purchase one new share at $29.50 for each six held, a total of 396,079 shares ($11,684,330) will be offered. Also, $22,000,000 of 4⅞ per cent sinking fund debentures, due 1977, will be offered to the public at 99 to yield 4.95 per cent to maturity. Proceeds will be used to repay Acme's $17,000,000 of various purpose notes and to help finance the firm's $23,000,000 construction program.

May 24

▲ Benjamin F. Fairless, president of the AISI, at the annual meeting, said that steel production capacity in the U. S. may show a greater increase in 1957 than the 5,000,000 tons added in 1956, and further stated that the industry's plans for 1958 are no less ambitious, declaring that over a long-range, capacity must be added at a rate of at least 3,000,000 tons a year.

▲ The AISC reported that shipments of fabricated structural steel in April, 1957 totaled 313,591 tons, compared with 305,009 tons in March, 1957 and 289,616 tons in April, 1956; bookings in April amounted to 360,351 tons, compared with 289,103 tons in March, 1957 and 378,937 tons in April, 1956. Backlog on April 30 was 3,416,778 tons.

May 27

▲ The AISI reports that the operating rate of the steel industry for the week of May 27 is scheduled at 87.8 per cent of capacity. This is equivalent to 2,246,000 tons compared with 2,212,000 tons one week ago and 2,370,000 tons one year ago. Index of production for the week is 139.8.

▲ The Bureau of Labor Statistics reported that the government index for April advanced 0.3 per cent to 119.3 per cent of the 1947–49 average, due chiefly to rising food costs; factory workers weekly take-home pay in April was 3 per cent above the 1956 level, but buying power was down nearly 1 per cent because of increased living costs.

▲ F. W. Dodge Corp. reported that construction contracts in the United States in April totaled $2,776,431,000, 9 per cent below April, 1956.

▲ Effective July 1, Allied Chemical & Dye Corp., will raise price of ammonia at least $8 a ton.

▲ Corporations marketed $3,600,000,000 in new securities for the first quarter of 1957, compared with $3,000,000,000 in the last quarter of 1956 and $2,300,000,000 in the first quarter of 1956. Debt issues offered for the first quarter of 1957 amounted to $2,800,000,000, an increase of $900,000,000 over the final quarter of 1956 and $1,100,000,000 greater than the first quarter of 1956.

May 29

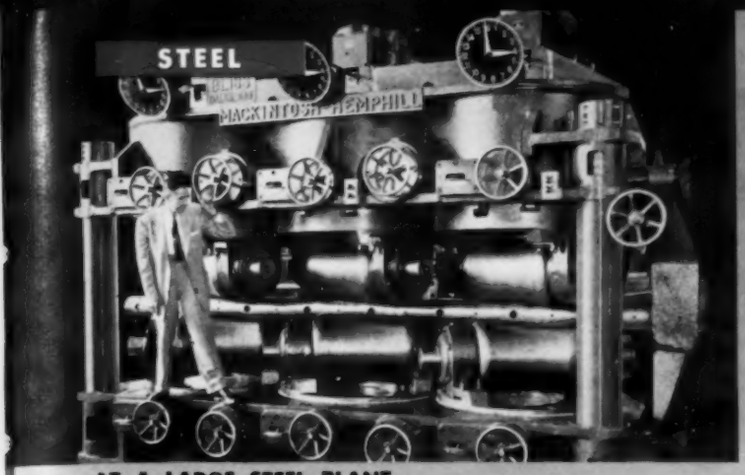
▲ The Lake Superior Iron Ore Assn. reported shipments of iron ore down the Great Lakes amounted to 2,994,689 gross tons for the week ended May 27, 1957 and compares with 2,911,795 tons moved in the same week in 1956.

May 31

▲ The shareholders of the Timken Roller Bearing Co. authorized an increase in the company's common stock from 2,500,000 to 6,000,000 shares and to split each outstanding share on a two-for-one basis, effective June 4, 1957. On May 21 the company filed a registration statement with SEC covering a proposed offer of 484,276 shares of common stock to its shareholders, at the contemplated ratio of one new share for each ten shares held after the split.

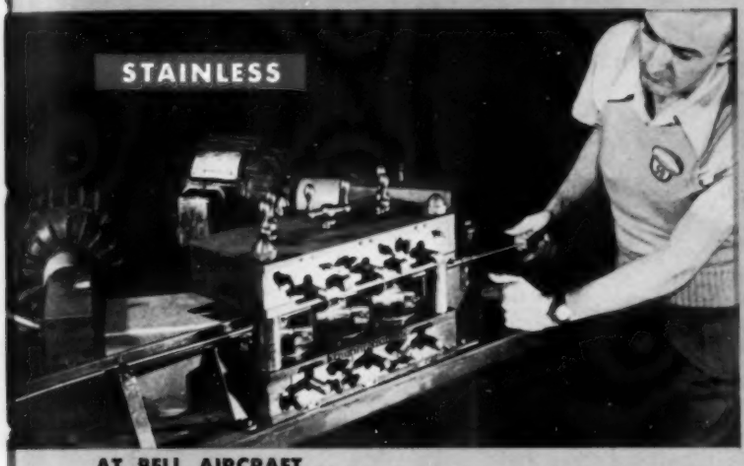
▲ Prices of secondary grades of steel scrap in Pittsburgh advanced $1 to $3 a ton, and a Pittsburgh district producer bought No. 2 heavy melting scrap at $43 a ton for local material.

▲ Shipments of iron and steel castings during March, 1957 amounted to 1,371,213 short tons compared with 1,336,078 short tons in February, 1957.

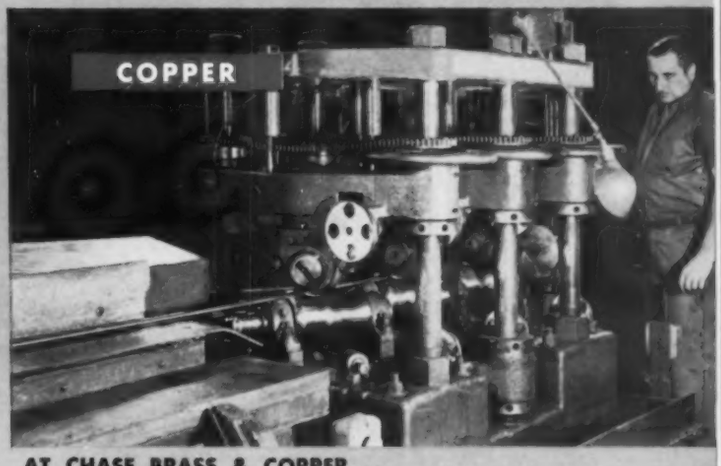


AT A LARGE STEEL PLANT...
This A-5 recently shipped to an eastern steel plant is the largest 6-roll straightener in the world; straightens electric-weld steel pipe in diameters between 4½" and 16", in 16-to-65 foot lengths at speeds up to 240 feet per minute. It illustrates the three-post design now available in large models of the Mack-Hemp straightener.

AT ALCOA...
This Model AX has recently gone into operation at Alcoa's New Kensington, Pa., plant. It straightens from 100 to 150 tons of aluminum alloy tubing every month. Guideless design and power drive to all six rolls enable Mack-Hemp to successfully production-straighten easily-marked aluminum tube.



AT BELL AIRCRAFT...
At this aircraft producer's Buffalo plant, this three-post Model AY straightens 3/16" O.D. 304 Stainless Steel tubing which Bell makes into rocket engine components. The machine raised Bell's straightening capacity from 570 feet to nearly 7500 feet per day... more than *thirteen* times as much!



AT CHASE BRASS & COPPER...
This Model AN, with capacity of ½" to 3" O.D. is one of three Mack-Hemp straighteners at Chase's Cleveland plant. The Models AXY, AX and AN together provide overlapping capacity for 3/16" up to 3" O.D., in straightening brass or copper tube and in "light tempering" annealed copper tube.

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The MACK-HEMP Guideless Rotary Tube Straightener

- All six rolls driven—no guides—surface of straightened tubing is unmarked.
- Eliminates end bends and ovality; provides premium straightness and roundness over full length of tube.
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- Speeds up to 800 feet per minute.
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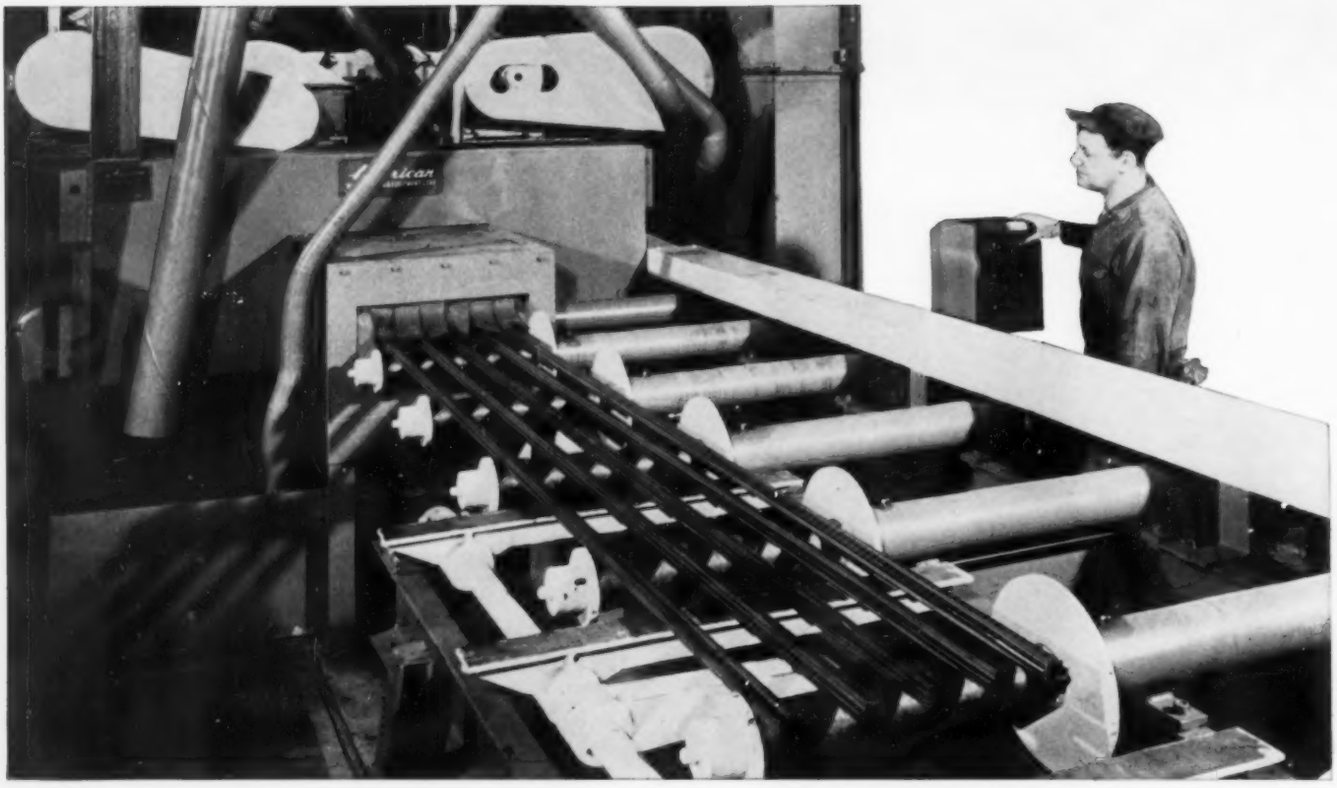

In Cleaning Bar Stock for Cold Drawing

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Mechanical Descaling

REDUCES COSTS — INCREASES PRODUCTION
REDUCES AT LEAST 90% OF ACID PICKLING NEEDS

Mechanical descaling with Wheelabrator airless abrasive blast cleaning greatly reduces the time formerly required by the slower, more costly method of pickling mill lengths of bars and thus speeds cleaning production while effecting significant savings.

Wheelabrator equipment can be designed to suit nearly any production requirement, and work-conveying methods through the blast cabinet are engineered to fit product and production needs.

For instance, the unit shown here is designed to deglass and descale hot extruded bars at a prominent steel mill. (Powdered glass is used as a lubricant in the hot steel extrusion process.)

This installation handles five bars at a time on a roll-type conveyor. Four Wheelabrator units, in fixed position, are so arranged that all surfaces of the many different sections of the extruded bars are covered with the abrasive blast and are thoroughly cleaned. The bars are given a 3 to 5 minutes pickle, lime coated and cold drawn for final sizing of the shape to required tolerances. This operation has proved much cheaper and faster than the previous pickling process. It is also possible to eliminate the acid pickle and lime coating in some cases.

Other Wheelabrator mechanical descaling installations have saved at least $1 a ton on round bars by effecting savings through reduction in pickle time and increased production.

Wherever steel must be descaled, whether it's strip, sheet, bar stock, structurals, slabs or billets — Wheelabrator Mechanical Descaling replaces or drastically reduces acid pickling requirements and effects savings in time, space, manpower and overall costs.

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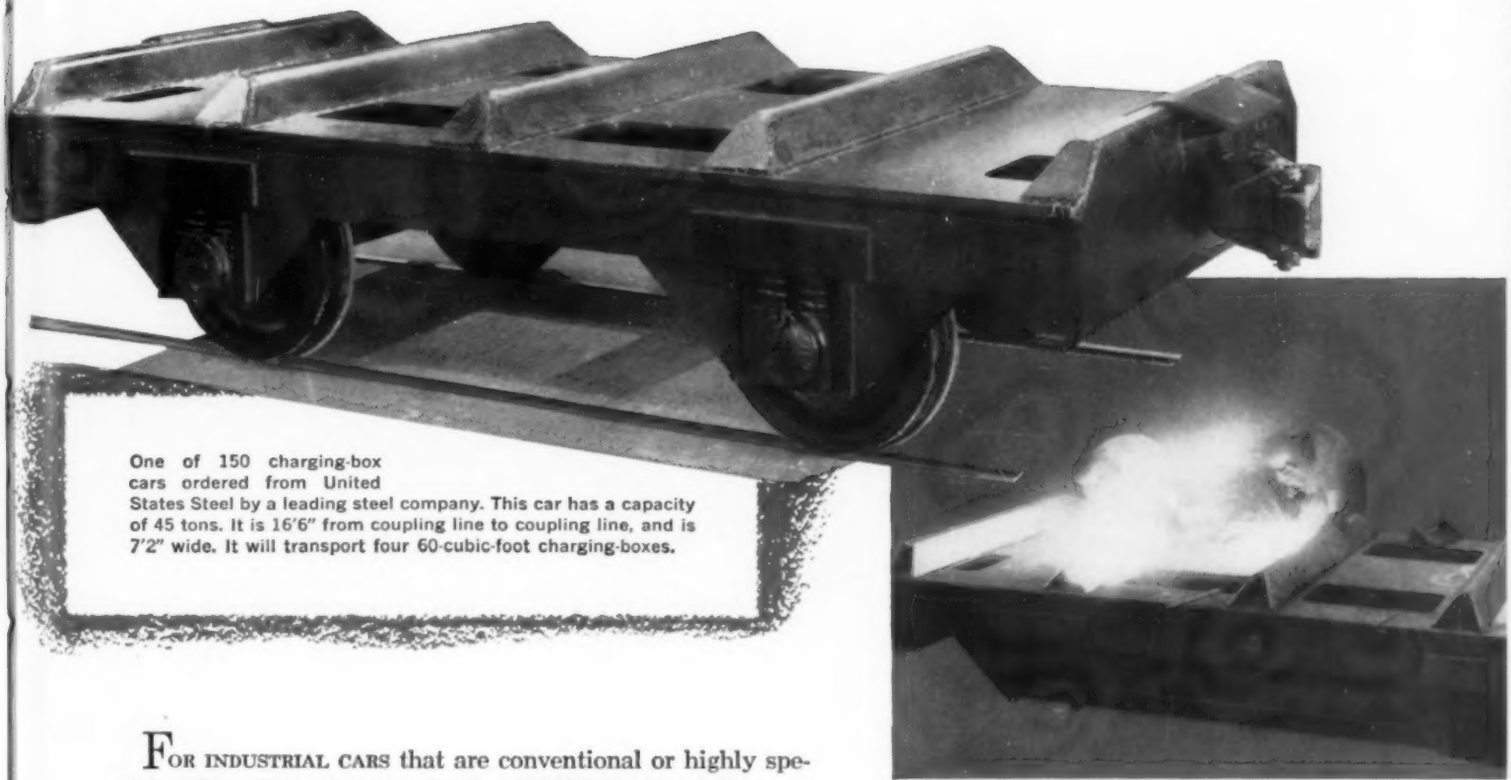


One of 150 charging-box cars ordered from United States Steel by a leading steel company. This car has a capacity of 45 tons. It is 16'6" from coupling line to coupling line, and is 7'2" wide. It will transport four 60-cubic-foot charging-boxes.

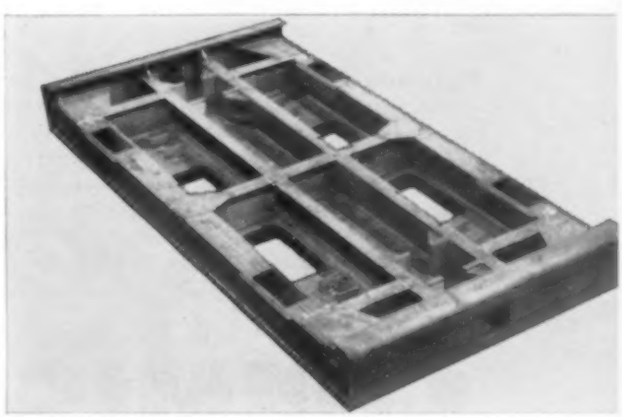
Separators for charging-boxes being welded to car. Separators are fabricated from welded steel plate.

FOR INDUSTRIAL CARS that are conventional or highly special, call on United States Steel. All USS-Designed Cars are custom-made to meet your exact specifications.

A good example is the charging-box car shown here—one of 150 cars being built to the general specifications of our customer. This all-welded steel car has a capacity of 45 tons, and will transport four 60-cubic-foot charging-boxes.

Car has eight "cutouts" in its inch-and-a-half steel upper deck plate to make it lighter. Its four wheels are equipped with outboard bearings, and it is for use on standard-gage track.

Capacity, running gear, and other design features of charging-box cars can be varied to suit your needs. Our engineers will be pleased to call at your convenience to discuss your requirements for this or any kind of industrial cars. For more information, meanwhile, send for a free copy of our 32-page illustrated booklet—"USS Custom Designed Cars."



Note rugged underframe of car.

USS INDUSTRIAL CARS

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

United States Steel Corporation
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Please send me a free copy of your 32-page booklet, "USS Custom Designed Cars."

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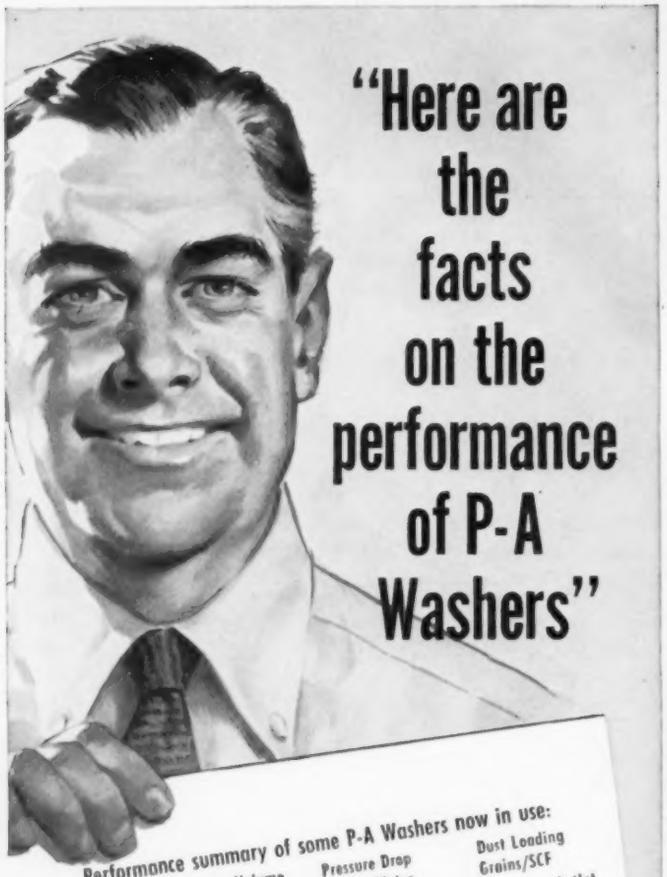

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Performance summary of some P-A Washers now in use:

Installation	Years Operated	Volume SCFM	Pressure Drop Inches Water	Dust Loading Grains/SCF Inlet	Outlet
A	4	78,000	30	3-19.0	.01-.04
B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure

These actual performance figures reflect the highly efficient operation of the Pease-Anthony washer. This venturi scrubber puts your full top pressure to work cleaning the gas. No secondary cleaner required for most installations. Present users report no maintenance problems. If you have a blast furnace scheduled for construction or rebuilding, plan now for P-A Venturi installation. Capacities up to 150,000 SCFM. Write for bulletin M-103.

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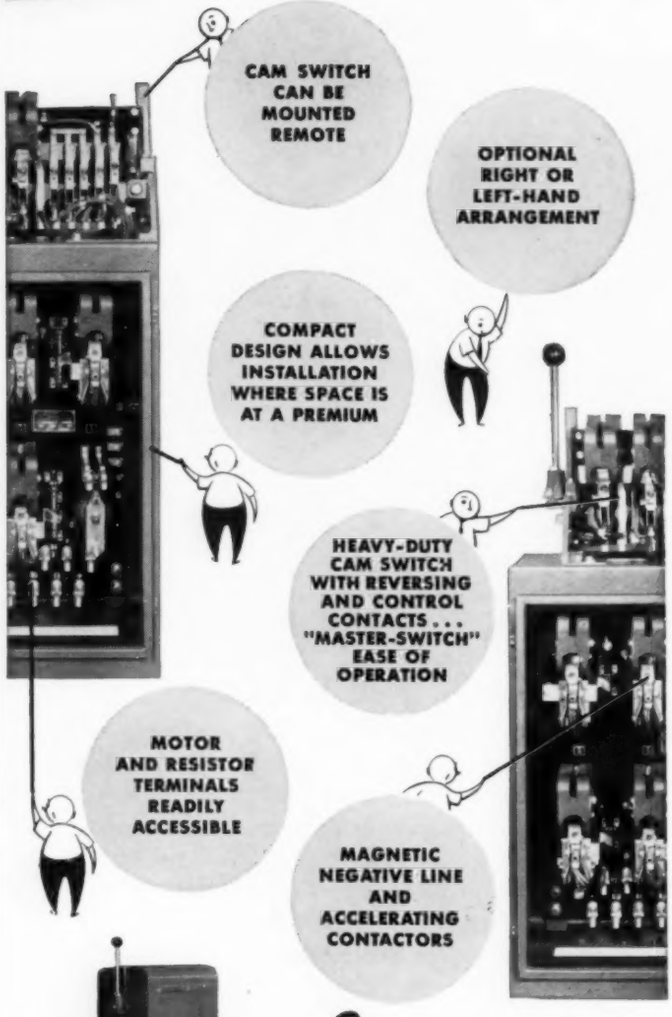
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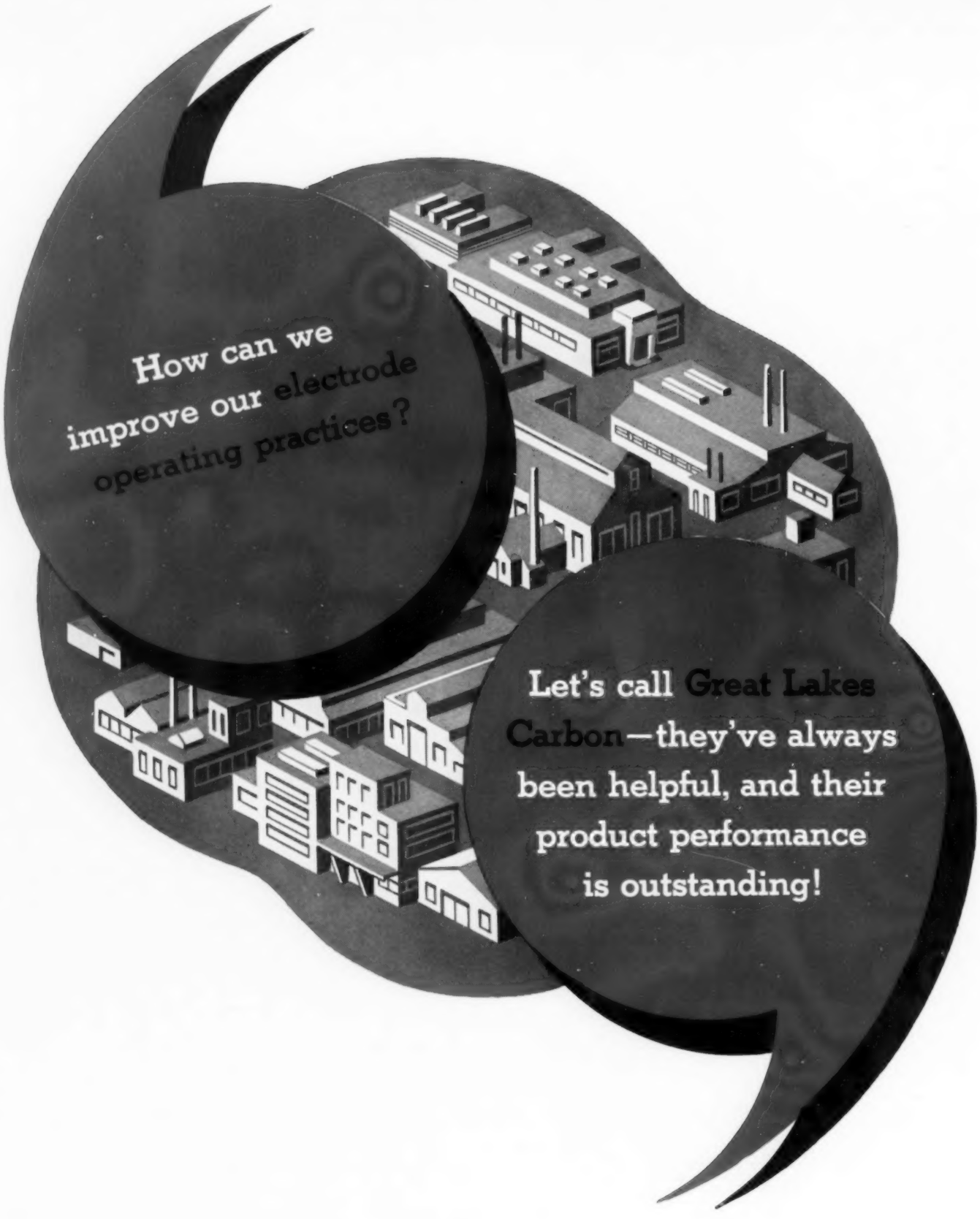
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Wayne "W.B." Yarnell
Chief Engineer.

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Not an ordinary job but one, nevertheless, that is typical of the type that CHICAGO CONCRETE CONSTRUCTION has developed a reputation for handling, is that of the mantle-up reline of a 26'-hearth blast furnace for which, a particularly-tight schedule was necessary. From blow-out to blow-in, the time allotted was a very short 36 days. The job not only consisted of completely tearing out and rebuilding this furnace, but also included the installation of the first complete system for proportioning air to the tuyeres.

By expertly analyzing the numerous jobs that had to be done, Wayne Yarnall coordinated the engineering and construction activities in such a manner that he had the respective work crews functioning with railroad-schedule tightness. Despite the vast complexities of installing this first air proportioning system, and despite the numerous operations that were involved in this complete tear-out-and-rebuild, the blow-in was made 34 calendar days after the furnace had been shut down.. two full days ahead of the previously-agreed-to-schedule!

Yes, where hours can mean the difference between a gain or a loss of thousands of dollars . . and where experience, know-how and seasoned manpower are called for, the firm to remember is the firm who seriously advertises . . . WANTED - - - A HARD JOB!

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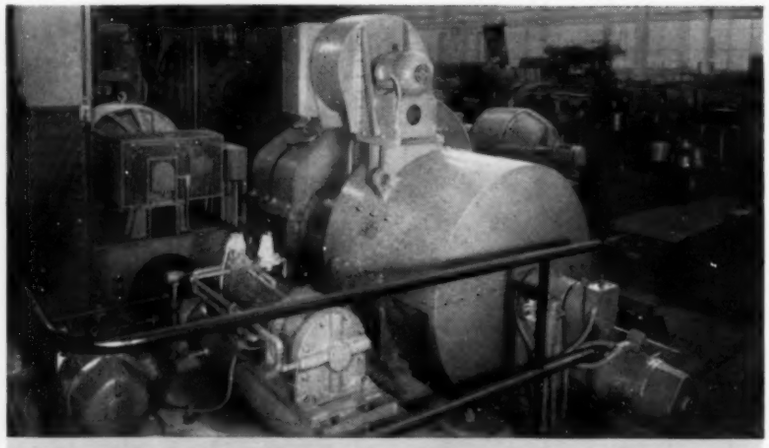
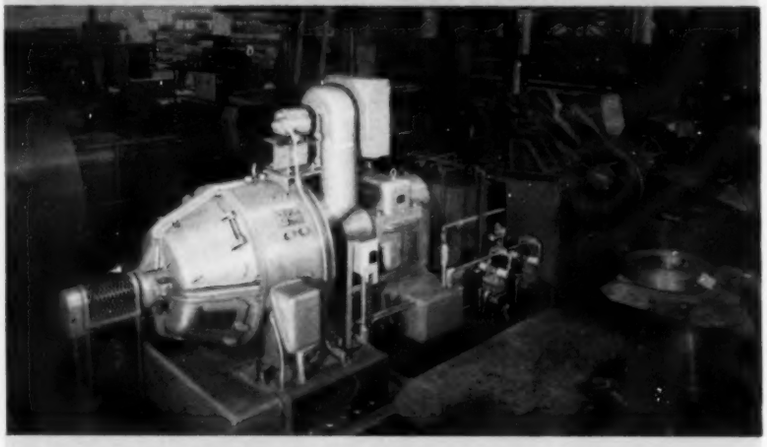
STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

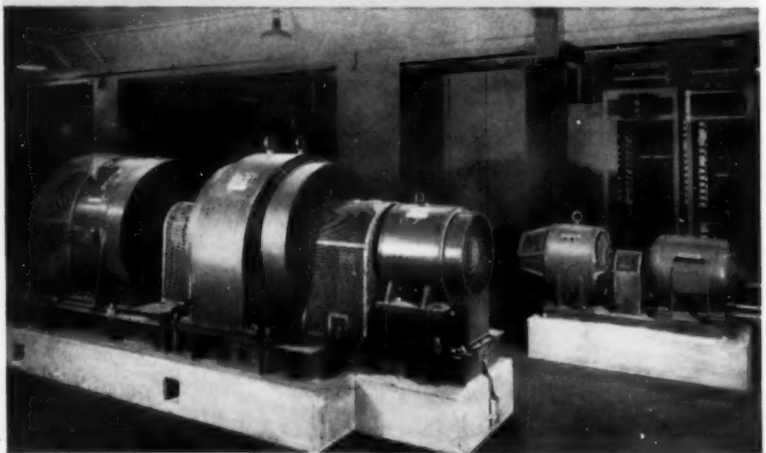
RG-27



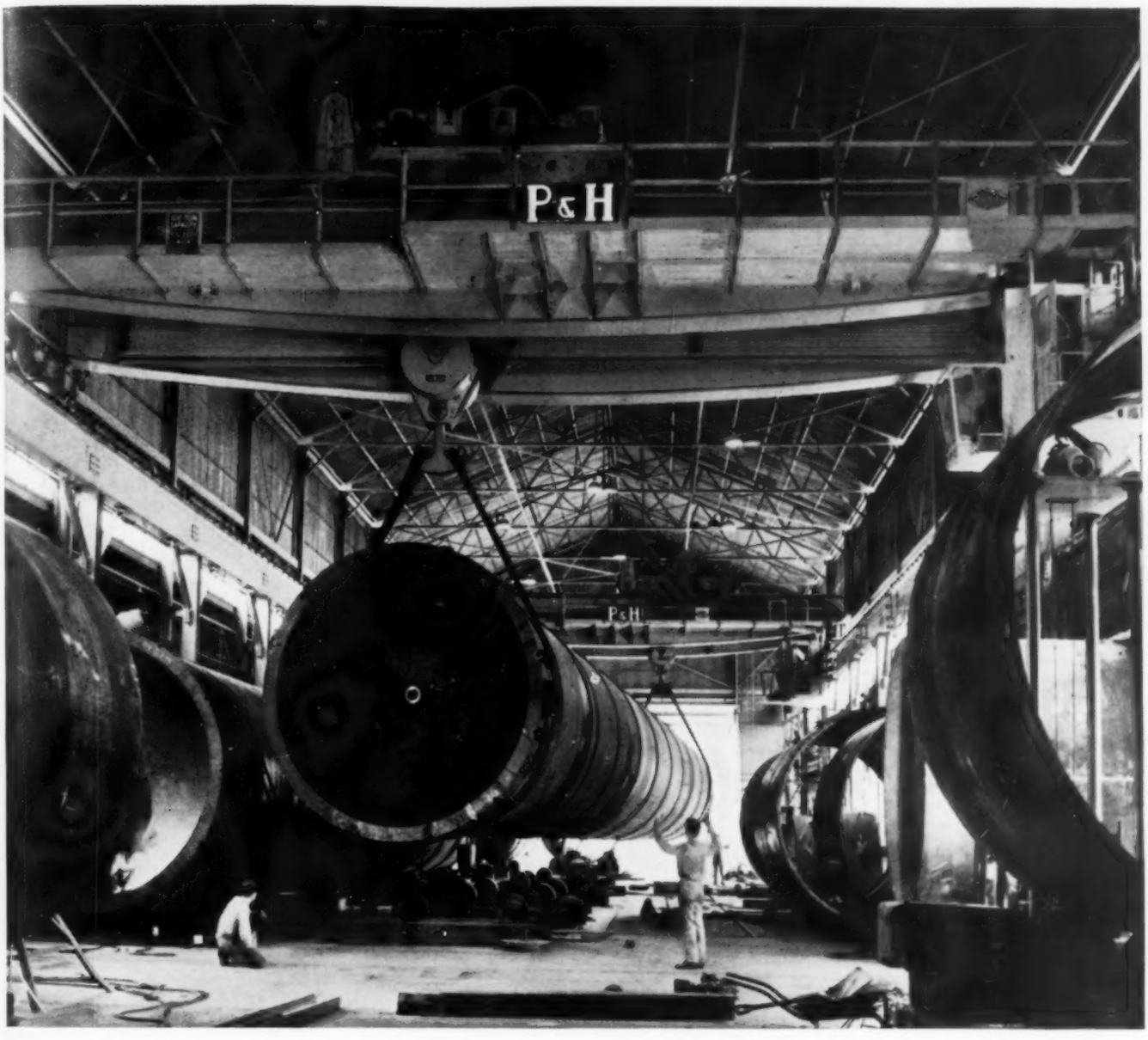
Main drive for the mill consists of an Elliott 500-hp, 575/1280-rpm, 600-volt, d-c motor, with top-mounted ventilating blower driven by an Elliott C-W motor. Uncoiler drive and blocker drive motors are seen at left and right.



The blocker-drive motor is 75 hp, 575/1280 rpm, 600 volt, also with top-mounted ventilating blower and filter.



The main motor-generator consists of a 500-kw, 600-volt d-c generator and a 15-kw, 250-volt exciter, driven by a 700-hp synchronous motor. At right is the motor-generator for powering auxiliary drives.



Easy does it!

with P&H Electronic Crane Control

Precise spotting of giant loads is far easier if you're using P&H Overhead Cranes equipped with P&H electronic "stepless" control.

This remarkable control makes possible an infinitely variable power application from no-load to full-load by providing a smooth "stepless" control response. As a result, tremendous loads can be spotted with exceptional accuracy — without the strain of a jerky "inching" operation.

P&H Electronic Crane Control helps reduce crane maintenance, too. It is a simple wiring circuit, yet it replaces 29 sets of contactors — points of heavy wear — found on other cranes.

Investigate this outstanding advance in overhead cranes! Write for "Electronic Crane Control" to Dept. 1086, Harnischfeger Corp., Milwaukee 46, Wis.

HARNISCHFEGER

P&H INDUSTRIAL DIVISION
MILWAUKEE 46, WIS.

HOW IMPORTANT IS

HIGH CONDUCTIVITY

IN BLAST FURNACE COPPER?

100% thermal conductivity requires the purest copper. But it's expensive, and usually too soft to endure the abrasion of the burden.

There are techniques we know that will keep conductivity high and still give you tuyeres and plates with good wear resistance.

Techniques in the deoxidization of molten copper, for one!

Casting techniques for another. By applying ingenuity in casting, it is possible to minimize alloy content and still get the hardness you need, without adversely affecting conductivity.

So, next time you talk about thermal conductivity above 90%, remember that it takes more than pure copper to make it practical. It takes superior metallurgical skill and foundry practice.

National Bearing leads the industry in just that skill and practice. We *guarantee* conductivity above 90% when specified by the customer.

It's all a matter of what importance you assign to *high conductivity* in your blast furnace copper. And how much you think it's worth.

Talk to us about it.

NBD maintains more than 500 tuyere patterns, including Wier, heavy-nose and angle-flow tuyeres, at Meadville, Pa.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue • St. Louis 10, Missouri

PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

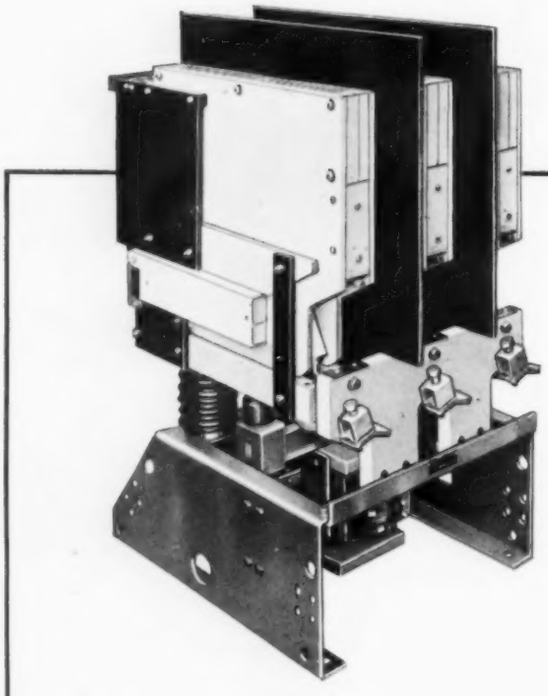
This NBD instrument measures thermal conductivity, using eddy currents and radio waves. It is used on test plugs at the furnace, and again on finished castings.

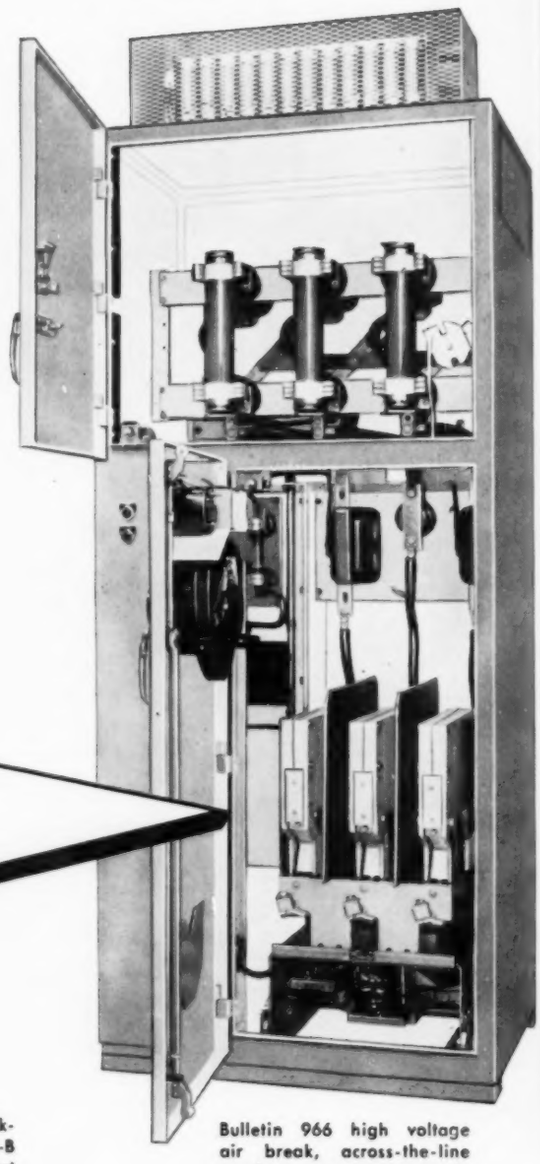
NBD machines butts of all tuyeres to assure perfect fit.

Air break starters

for high tension motors up to 3000 hp, 2501-4600 v.

The Sign of
QUALITY
Motor Control





Allen-Bradley high voltage contactors incorporate the same remarkable design simplicity on which the QUALITY reputation of A-B low voltage motor control is based. Thus, the one moving part principle, plus double break, silver alloy contacts, assures long life and minimum maintenance inspection.

Bulletin 966 high voltage air break, across-the-line synchronous motor starter in NEMA Type 1 enclosure.

With the NEW air break high voltage contactor as the basic unit, a complete line of Allen-Bradley high tension starters has been developed . . . up to 3000 hp, 2501-4600 volts.

They can be supplied for full voltage or reduced voltage starting, and all starters are equipped with current limiting fuses. All starters have an interrupting capacity of 150,000 kva at 2300 v and 250,000 kva at 4600 v. For safety reasons, the front-operated disconnect switch is interlocked with the doors of the enclosure and also with the high voltage contactor.

Overload relays with current transformers provide continuously reliable overload protection.

The simple design . . . with only ONE MOVING PART . . . and the double break, silver alloy contacts which are always in good operating condition . . . has created a new standard for maintenance free, high voltage motor control.

Send for the Allen-Bradley Handy Catalog describing the complete Allen-Bradley high voltage line.

Allen-Bradley Co.
1343 S. First St., Milwaukee 4, Wis.
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ALLEN-BRADLEY SOLENOID MOTOR CONTROL

QUALITY

ANOTHER OF THE GARLOCK 2,000

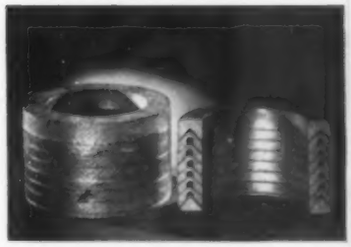
1000-Ton 4 column Farquhar Press forming heavy steel plate. Main rams and pull back rams are equipped with CHEVRON Style 431.

1000-TON PRESS
attests "stamina" of Garlock CHEVRON* packing

The shock absorbed during operation by this Farquhar 1000-Ton, 4 column press makes necessary the use of a packing that will automatically compensate for sudden changes in pressure. In addition, the packing must be extremely durable to minimize downtime.

That's why engineers at A. B. Farquhar Division of The Oliver Corporation, York, Pa., specify Garlock CHEVRON exclusively for the main rams and pull back rams of this press. CHEVRON'S unique construction permits free operation of rams at all pressures. It automatically tightens or eases-off as pressures increase or decrease . . . prevents leakage without hampering operation.

CHEVRON is another vital part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every conceivable need—the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today or write for CHEVRON Folder AD-115.



Style 431 CHEVRON assures low friction, positive seal, lasts longer than ordinary V-type packing, and works efficiently in shallow stuffing boxes.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

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GARLOCK

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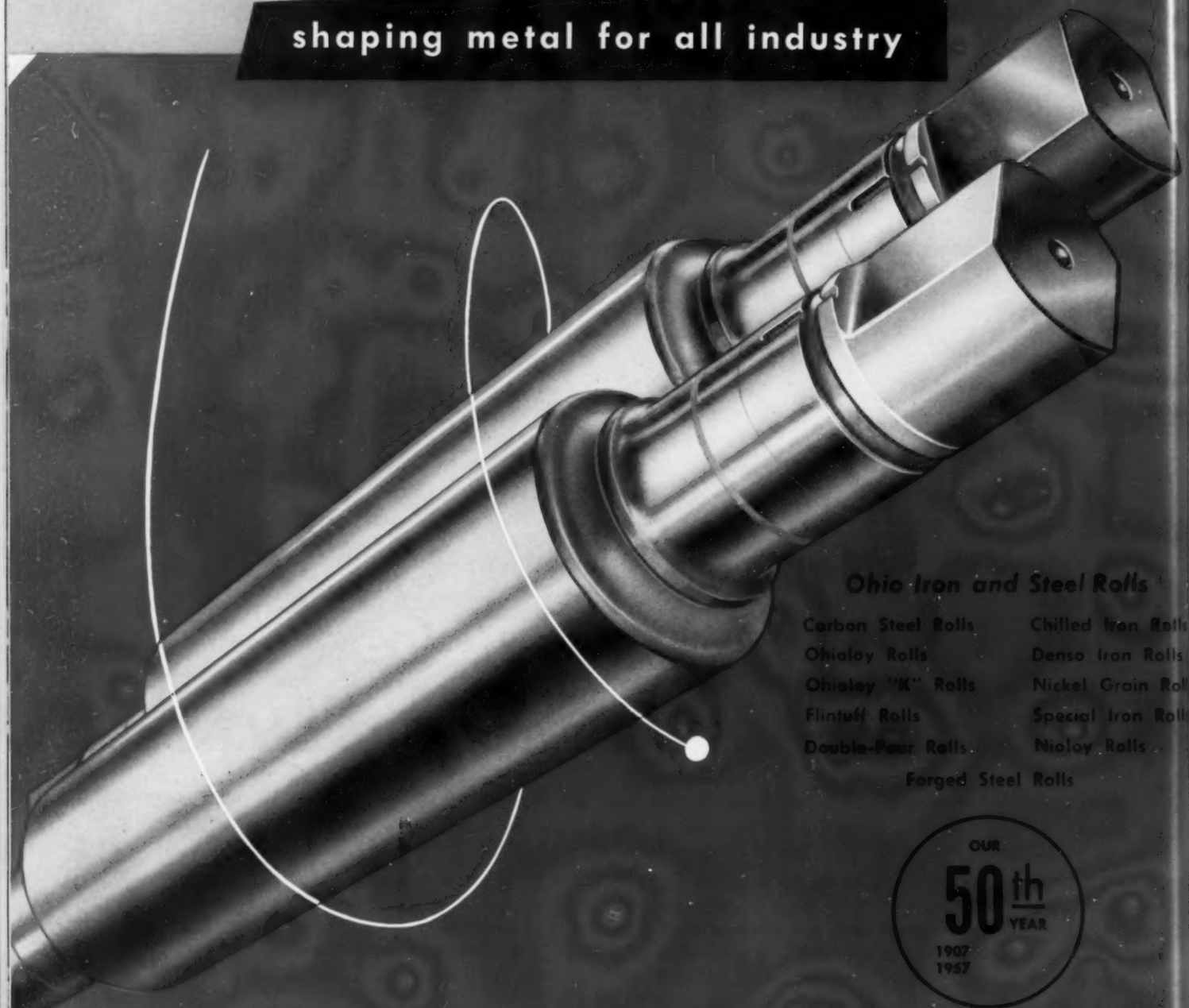
Ohio Rolls

shaping metal for all industry



Ohio Iron and Steel Rolls

Carbon Steel Rolls
Ohioloy Rolls
Ohioloy "K" Rolls
Flintuff Rolls
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Chilled Iron Rolls
Denso Iron Rolls
Nickel Grain Roll
Special Iron Roll
Nioloy Rolls
Forged Steel Rolls

OUR 50th YEAR
1907
1957

THE OHIO STEEL FOUNDRY CO.
LIMA, OHIO

Plants at Lima and Springfield, Ohio

OR3

Industry News...

SHIP POWER EQUIPMENT FOR ARGENTINE PLANT

▲ Two electrical generators have been shipped to the site of a $250,000,000 steel mill project in Argentina as part of a $60,000,000 loan by the Export-Import Bank.

The new integrated plant will be located at San Nicholas (150 miles north of Buenos Aires), and will have an annual ingot capacity of 558,000 ingot tons. The project will be operated by Sociedad Mixta Siderurgia Argentina, S.A. (Somisa).

The 26,500-kw generator units are part of more than $14,000,000 in equipment ordered to date from Westinghouse Electric Co. for the steel mill and its power plant. Now under construction are large motors and control for a blooming mill, a rail and structural mill and a hot strip mill, as well as turbines and additional electrical apparatus for the power plant.

According to W. E. Knox, president of Westinghouse Electric International Co., Somisa plans to purchase a total of $100,000,000 worth of United States-built equipment for the plant.

Arthur G. McKee & Co. is in charge of design and construction. United Engineering and Foundry Co. is furnishing mechanical equipment for the hot strip and blooming mills. Other mill builders with major contracts on the project are Morgan Engineering Co., Morgan Construction Co., and Loftus Engineering Corp.

RYERSON TO ENLARGE ITS PITTSBURGH PLANT

▲ An expansion program at its Pittsburgh, Pa., steel service plant which will increase capacity more than one-third has been announced by Joseph T. Ryerson & Son, Inc. Charles L. Hardy, president, said that the construction would begin this year with completion in 1958. Cost of the building, machinery and other operating equipment is estimated at approximately $1,000,000.

The addition will consist of a crane served span 110 ft by 480 ft, which will be erected adjoining the present building. The new space will be used principally for larger and more diversified stocks of structural, plate, reinforcing bar and sheet steel. A 15-ton, two-hoist bridge crane will be installed, along with new cutting and other steel handling equipment. The plant now has facilities for fabricating concrete reinforcing steel bars and this operation is expected to grow in importance.

MANNESMANN OPENS NEW SEAMLESS TUBE MILL

Mannesmann Tube Co., Ltd., officially opened its new plant at Sault Ste. Marie, Ontario, Canada, on June 15. The plant is fully automatic and will manufacture tubes ranging in size from 4½ in. to 10¾ in., OD. Shown above is revolving furnace with conveyor to piercing mill.

INSTALL WIRE FABRIC MACHINE AT CUYAHOGA

▲ A welded wire fabric machine has been placed in operation at the Cuyahoga Works of U. S. Steel Corp.'s American Steel and Wire Division in Cleveland, Ohio.

The welded wire fabric machines are more than 10 ft tall and 132 ft in length. Mounted to the rear of the machines are 49 reels containing from two to four miles of wire.

Welded wire fabric is composed of longitudinal and latitudinal, or transverse, wires spaced from one to 16 in. apart by a predetermined setting of a dial. As the wires enter the machine, mechanical fingers position them and sets of electrodes weld them at the cross points. Each machine will produce some 1700 tons of welded fabric a month at capacity operation.

To accommodate the machines a new building 107 x 470 ft was erected, including an enclosed railroad siding, and a truck dock for expeditious shipment. Two big overhead cranes were installed for transporting the fabric from the machines to the storage area, where there is capacity for 750 to 1,000 tons of the durable wire reinforcing material.

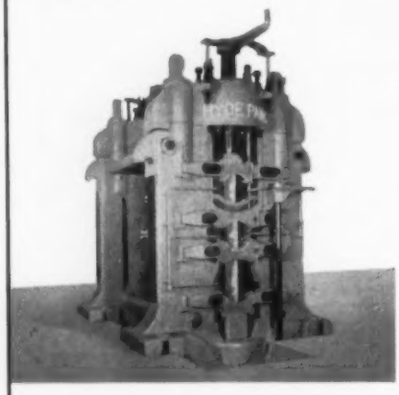
AIR REDUCTION WILL EXPAND LORAIN PLANT

▲ Plans for a $3,000,000 expansion that will more than double the production facilities for gaseous and

Hyde Park
RED CIRCLE Rolls ALLOY-CHILLED

Rolling Mill Equipment

For more than 50 years Hyde Park Steel Mill equipment has been helping American industry lead the world—equipment such as—



Bar Mills
Merchant Mills
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Machine Work

For finer finish, long life and greater tonnage, specify Red Circle Rolls.

Hyde Park
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland Co., Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

liquid oxygen at Lorain, Ohio, have been announced by John A. Hill, president of Air Reduction Co.

The expansion, which will boost daily capacity from the present 985,000 cu ft to 2,235,000 cu ft upon completion, is made necessary by the great increase in oxygen consumption by local industry for open-hearth and Bessemer furnaces, heat treating, welding, flame cutting and various other industrial processes.

Construction of the addition to the Lorain plant is expected to be under way by July, and will take about a year to complete. It is part of Airco's $24,000,000 general expansion program for 1957.

INSTALLS NEW MILL IN 12 CALENDAR DAYS

▲ A construction "first" in the field of steel plant expansion is claimed by The H. K. Ferguson Co., in connection with a project for Dominion Foundries & Steel Limited of Hamilton, Ontario. The job involved removal of an old slabbing mill and replacing it with a new one, largest of its kind in Canada. The record concerned the small amount of "downtime"—only 12 calendar days elapsed between shutting down the old mill and putting the first ingot through its replacement.

The downtime is believed to be half the amount required for any similar operation in the United States and Canada. Preceding the "big switch," some six months of carefully planned and scheduled work were required.

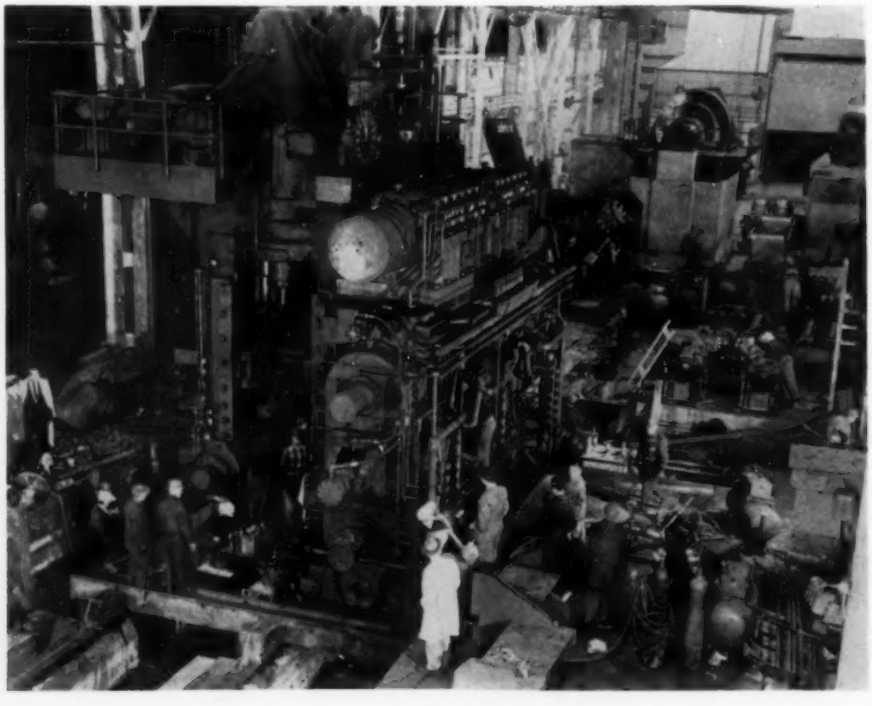
According to Ferguson officials, the first step was to pre-assemble completely the new mill, a 46-in., 2-Hi Universal-Type slabbing mill. This work was performed on temporary foundations 50 ft away from the point of eventual installation, the place occupied by the old mill which continued in operation.

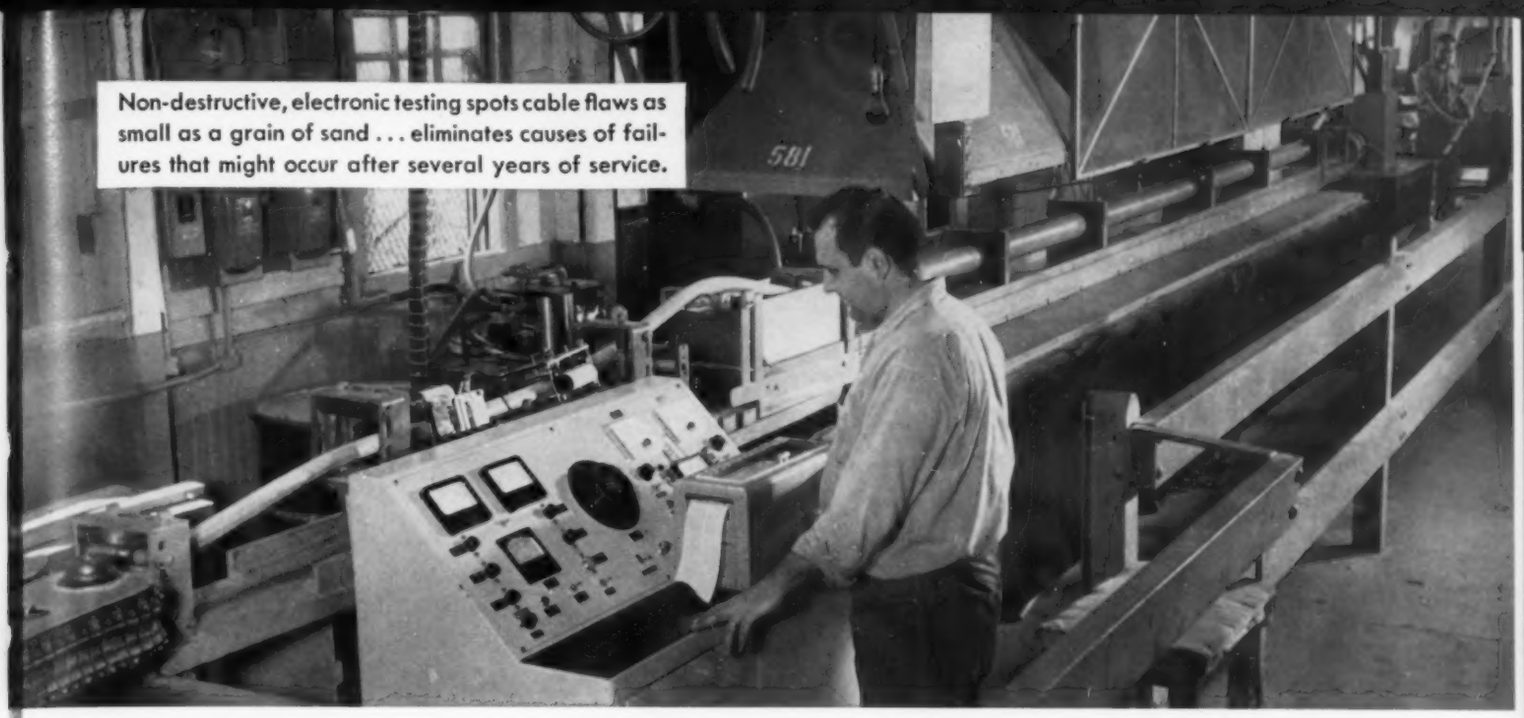
Also prefabricated was a giant "cage" which would be later used as forms for the new permanent foundations. The forms were completely pre-equipped with reinforcing steel principal anchor bolts, ventilation ducts and the steel scale sluice trough. In addition, new piping and electrical systems were installed beside the old mill.

Actual replacement operations began May 5 with the final shutdown of the old mill. As soon as it was dismantled and removed, its old foundations were blasted out and the previously prepared forms were lowered into place. A special quick-setting concrete was used to save normal curing time. All work was performed on a round-the-clock basis.

Two high-polished steel rails or skids, to which special lubricants were applied, were used to move the

Slabbing mill is inched along lubricated rails toward foundation in background.





Non-destructive, electronic testing spots cable flaws as small as a grain of sand . . . eliminates causes of failures that might occur after several years of service.

now all Okonite rubber strip-insulated cables rated above 2kv undergo the most searching test in the industry

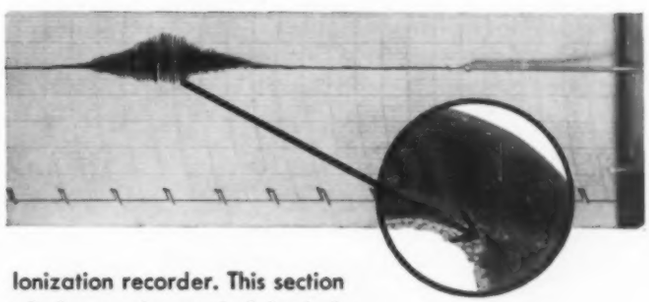
The Gooding Test Train, an Okonite development, can literally peer through every inch of solid dielectric cable to pinpoint flaws for removal or correction.

Two years' experience in regular production has proved that the Gooding Test Train detects flaws heretofore unrevealed even by the highest industry voltage tests or full-reel corona tests. Now that this valuable method of quality control has been thoroughly established, Okonite has extended its testing range to all strip-insulated cables rated above 2kv.

The entire cable passes through a series of three test units which provide unequalled assurance of successful service. The Gooding Test Train is used on strip-insulated cables in addition to Okonite's self-imposed, factory high-voltage acceptance tests which exceed industry specifications.

UNIFORMITY TEST—A uniformity gauge continuously checks insulation thickness to locate any thin spots.

IONIZATION TEST—The tiniest voids and imperfections are detected and located by measuring the corona level of the cable inch-by-inch. To pass, a cable must not show any trace of corona at a test voltage that is 1½ times the rated voltage of the cable. Defects that might escape any other known factory acceptance tests show up clearly on the associated ionization recorder. Defects of this kind can cause premature failure after only a few months' or years' service.



Ionization recorder. This section of the continuous inch-by-inch ionization test shows the recording of a defect in the insulation.

X-RAY TEST—A 250,000-volt X-ray machine can be used to study the nature and extent of any flaws located by the first two units.

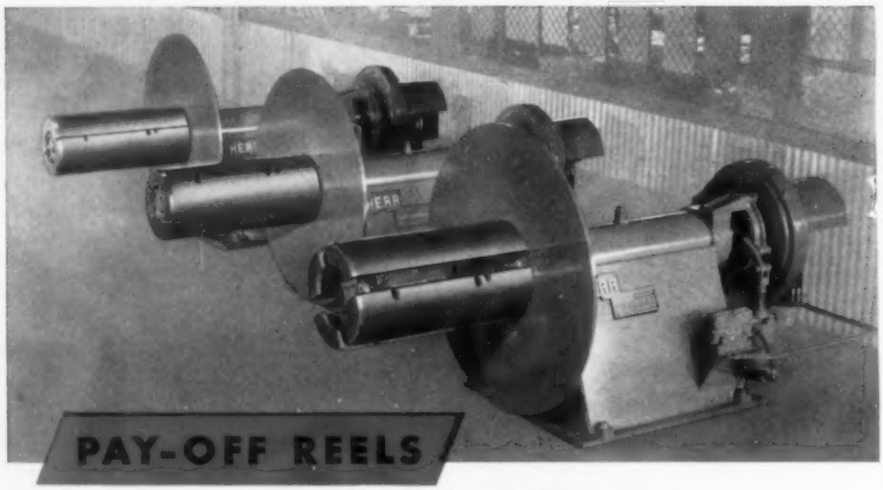
For additional information about this revolutionary testing method, write for Bulletin IS-1100. The Okonite Company, Passaic, N. J.

4702

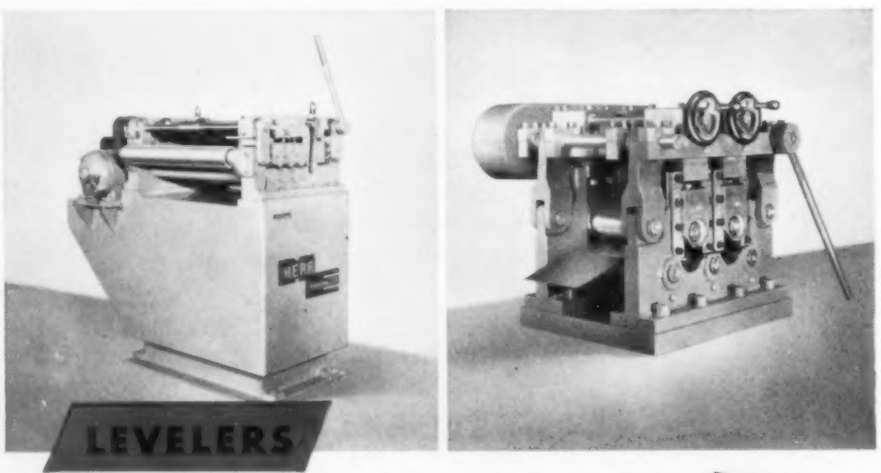
where there's electrical power... there's **OKONITE CABLE**

HERR EQUIPMENT

"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"



Types and sizes for coils weighing from 5,000 to 50,000 lbs. and up to 84" wide. Fixed, adjustable or automatically aligning bases. Timken bearings. Can be equipped with threading drive, also automatic speed compensating drive for feeding presses.



2-High and 4-High types. Driven and pull-through designs with quick release, for handling an extremely wide range of materials, widths and gauges. Rolls can be rubber covered if desired for easier adjustment and handling high finished materials.

Write for fully descriptive Bulletin No. 561 today!

THE HERR EQUIPMENT CORPORATION

1270 VINE STREET • WARREN, OHIO

CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

new mill to the point of final installation. Movement was provided by a hydraulic jack which literally inched the unit into place. The move was completed on May 17.

The project is a part of an $88,000,000 expansion program of Dominion Foundries. Six major projects in this program have been carried out by the Ferguson Co.'s subsidiary, H. K. Ferguson Co. of Canada Limited in a joint venture with Patterson-Emerson-Comstock International. They include installation of equipment for a 56-in. cold reduction strip mill, Canada's first fully automatic continuous galvanizing line, a second electrolytic tinning line, a continuous annealing line and a new 2000 ton-per-day blast furnace, which was erected by Ferguson in the record time of 10 months from the start of field work.

ORDERS 8 INDUSTRIAL LOCOMOTIVES FROM GE

▲ The United States Steel Corp. has ordered eight industrial locomotives from General Electric Corp. to handle expanded activities in three of its plants. Diesel-electric units, rated at 80 to 85 tons, are included in the contracts.

Four 80-ton locomotives will be put into service at U. S. Steel's Gary, Inc., Plant. They will be fitted with narrow bodies because of space limitations at the steel works and for extra speed they will operate with a 16 to one gear ratio instead of the usual 19.9 to one. These units, of standard gage, will be similar to three that have been in service at Gary for four years.

U. S. Steel's South Works at South Chicago will receive three 85-ton narrow gage locomotives.

The other locomotive called for in the order, an 80-tonner, will go to the Duquesne Works at Duquesne, Pa. It will be narrow gage.

CONTRACT AWARDED TO EICHLEAY CORP.

▲ A five million dollar contract was awarded by the American Brass Co. for the completion of their new aluminum plant at Terre Haute, Ind.

The new plant, covering approximately 400,000 sq ft, will produce aluminum strip, sheet, tube and

Major Steel Producer Orders Two More Koppers Electrostatic Precipitators for Gas Cleaning

Leading Steelmaker has ordered 15 Koppers Electrostatic Precipitators since 1947

SUCCESSIVE orders over a nine-year period prove the efficiency and economy of Koppers electrostatic precipitators at the plants of one of the nation's top steel producers.

Proves Performance on the Job

This industry leader installed its first Koppers electrostatic precipitator in 1947 at a Pennsylvania plant. Additional orders followed. Koppers units now operate in the company's plants in Maryland and Pennsylvania. Two factors spurred re-orders. Koppers units were economical and efficient. Koppers engineers were able to supply a wide range of CFM capacities.

Supplies a Wide Range

These Koppers electrostatic precipitators range in capacity from 33,334 CFM to 120,000 CFM. Guaranteed efficiency runs as high as 99.2% and each Koppers unit has exceeded its guaranteed performance. Engineering know-how enables Koppers to economically satisfy each individual application.

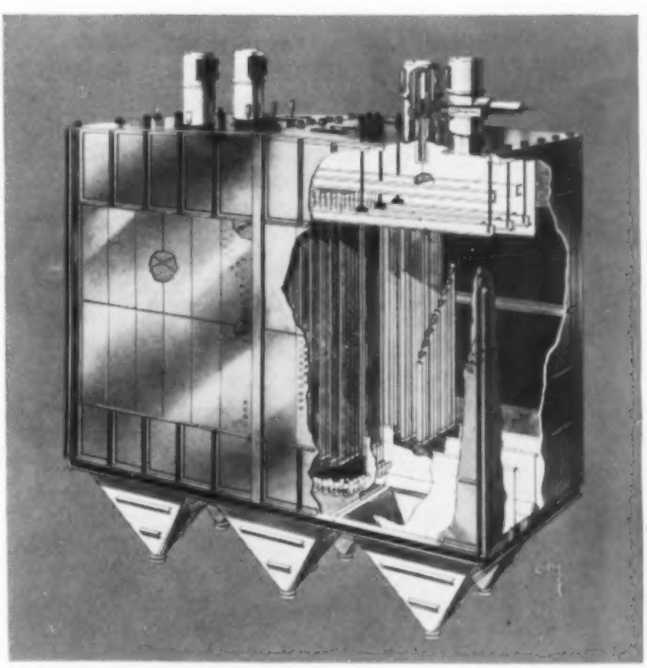
Meets Individual Plant Needs

Koppers custom-designs each electrostatic precipitator for its particular application. It may be at a blast furnace or an open hearth furnace, using either hot or cold metal process. It may be for hot scarfing or detarring coke gases. Whatever the job, Koppers provides highly effective gas cleaning at low cost per foot of gas processed.

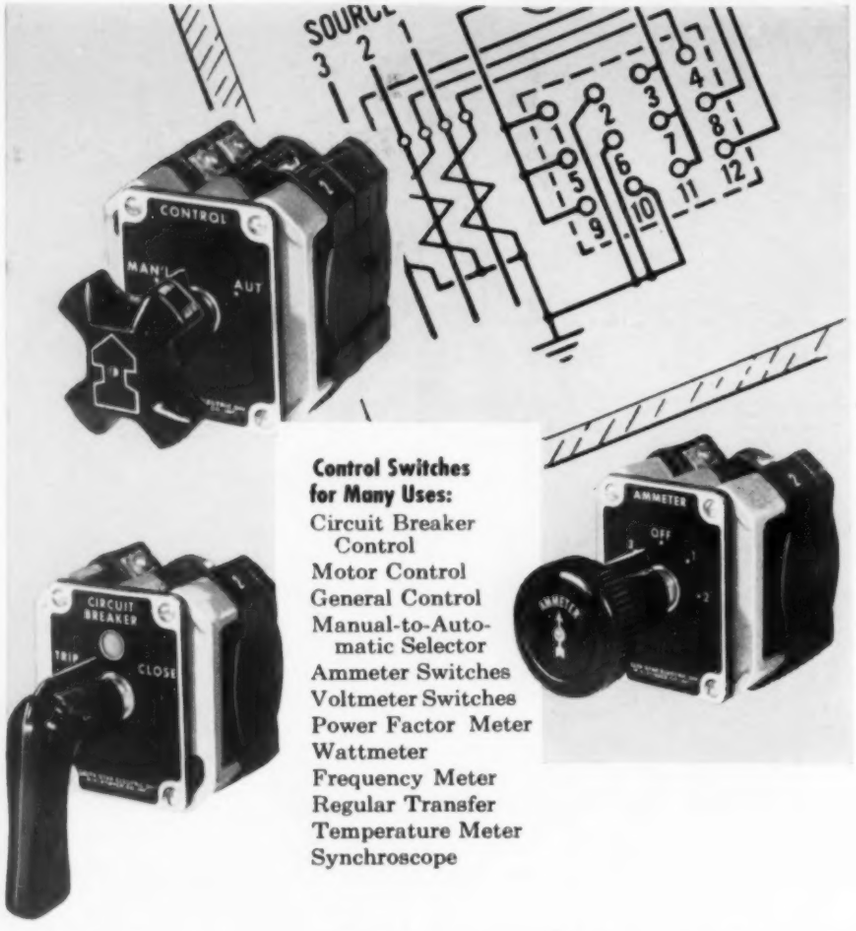
Backed by Know-How

Koppers has over 75 years' experience in industrial gas cleaning. In addition, Koppers maintains extensive research facilities at Verona, Pa., and Baltimore, Md. Manufacturing facilities at Baltimore produce a complete line of gas cleaning equipment for every size and type of plant.

You can put all of this experience and equipment to work solving your gas cleaning problem. Just write KOPPERS COMPANY, INC., Metal Products Division, Industrial Gas Cleaning Dept., 8306 Scott Street, Baltimore 3, Maryland.



Cutaway photo of a Koppers electrostatic precipitator shows shell, vibrators, and collecting and discharge electrodes. The actual design and arrangement of elements vary widely because Koppers electrostatic precipitators are custom-designed to fit the requirements of each particular application.



Control Switches for Many Uses:
Circuit Breaker Control
Motor Control
General Control
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Ammeter Switches
Voltmeter Switches
Power Factor Meter
Wattmeter
Frequency Meter
Regular Transfer
Temperature Meter
Synchroscope

Need rugged Control Switches? See Delta-Star's new line

These new Type M-2 Delta-Star control switches designed for D.C. or A.C. service give you important new features that mean improved operating efficiency and economy.

1. **Versatility**—designed for many uses from motor controls to synchroscopes. Switches are rated 20 amps. continuous rating with 250 amp. three-second rating.
2. **Compactness**—only 3⅞ in. high by 3¼ in. wide; new design permits easy wiring, quick inspection.
3. **Rugged and long-lasting** — heavy duty parts; high Delta-Star quality construction.
4. **High interrupting capacity** — single break contacts rated 25 amps. at 250 volts a.c., double break rated 75 amps.

Delta-Star now offers premium control switches at regular prices. Ask your Delta-Star representative about them or write *Delta-Star Electric Division, H. K. Porter Company, Inc., Chicago 12, Illinois. District offices in principal cities.*

HKP DELTA-STAR ELECTRIC DIVISION
H. K. PORTER COMPANY, INC.

shapes. Eichleay's contract calls for full responsibility—consisting of complete mechanical installation, electrical installation and piping of all equipment, including foundation and continuation of substructure work.

Besides machinery and equipment installations, the project includes the installation of all auxiliary structure and facilities such as waste treatment plant, sewage disposal plant, pump house, reservoir, interior office and sanitary facilities, roadway, loading and unloading docks and final yard grading.

About a year and a half will be required to complete the project.

ANNOUNCES EXPANSION AND ACQUIRES FIRM

▲ The A. A. Straub Co. Inc., 4930 Grayton Road, Cleveland, Ohio, has announced a major plant expansion program in 1957. The firm manufactures atmosphere generators and allied equipment for the steel, chemical and petroleum process industries.

Office space will be more than doubled to provide adequate facilities for an expanded engineering department and for additional administrative personnel. In the near future, an addition of more than 5000 sq ft of production space is planned. The additional production space is needed for the prefabrication and assembly of large components manufactured by the company.

At the same time, the company announced the stock purchase of Furnace Engineers, Inc., of Pittsburgh. The new officers of the firm were announced as A. A. Straub, president and general manager; J. H. Woods, vice president and William R. Nichols, secretary and treasurer.

Mr. Straub stated that all of the patents, engineering drawings and a selected group of technical personnel will remain with the firm to assure continuity of service to present customers.

At the present time, special efforts will be placed on direct-fired, bell-type annealing furnaces for coils, sheets and wire. The company has developed a new principle for this type of furnace, which eliminates the need for alloy steel tubes which have been a constant source

of difficulty in the past. Furnace Engineers also specializes in the design and construction of galvanizing furnaces for tubes, sheets and metalware.

AWARDED SOAKING PIT CONTRACT FOR GARY

▲ United States Steel Corp.'s Gary Works has placed a contract for the erection of 48 one-way fired soaking pits equipped with jet pump recuperating systems with Surface Combustion Corp.

The soaking pit installation will consist of 12 four-hole batteries; dimensions of pits will be 27 ft long, 9 ft 6 in. wide and 15 ft deep. Covers will be operated by electronic remote control from crane cabs. The contract includes all foundations, coke handling equipment and soaking pit building trackage.

The 48 soaking pits will be a part of the U. S. Steel's 46-in. slabbing mill expansion program with a rated annual capacity of 4 million tons.

GULF OPENS TWO NEW RESEARCH BUILDINGS

▲ Two new buildings, designed specifically for research to reduce drilling costs and increase the amount of petroleum recovered from oil fields beyond the present average of about 50 per cent, were opened at Gulf Oil Corp.'s Harmarville, Pa., Research Center.

The structures will be used in an intensive program of production research. An ultimate staff of 150 scientists, engineers and technicians is planned.

The main laboratory and office building will be shared by two divisions of Gulf Research & Development Co. with closely related aims, the Production Engineering Division and the Reservoir Mechanics Division.

The two divisions are under the supervision of R. A. Morse, associate director of Gulf Research & Development Co. E. Topanelian, Jr., is director of Production Engineering Division, and Dr. M. R. J. Wyllie is director of Reservoir Mechanics Division.

BEGINS OPERATIONS AT NEW CONN. BAR MILL

▲ The new cold-finished bar mill of Jones & Laughlin Steel Corp. at

Keystone integrated aluminum conductor systems feature long life, minimum downtime, low installation costs, increased safety and high current capacity. Surrounding photo shows system being installed.

No winter downtime with Keystone Aluminum Conductor System

For two winters—and going into the third—Niagara Mohawk Power Company, Buffalo, has enjoyed trouble-free service with a Keystone integrated aluminum conductor system. The system replaced one of wire used with Niagara's traveling coal storage towers.

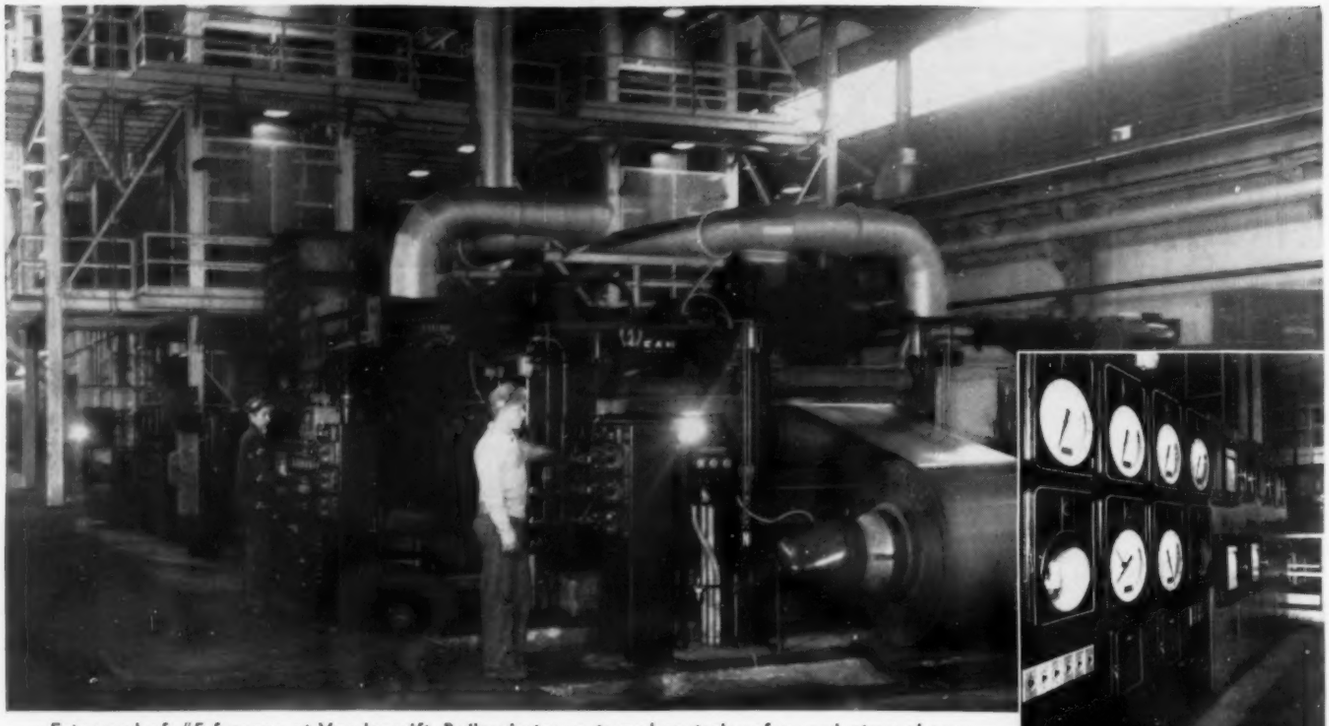
Service conditions are severe here. Ice is a big problem. Sulphuric acid fumes from coal piles cause corrosion. But with aluminum Inverted-V Keystone conductors and enclosures, these problems are solved.

Other advantages of Keystone integrated conductor systems improve operations indoors, too. Low voltage drop—rugged components—no wires to burn down. Steady operation is assured.

For further case history information and data on use of Keystone Aluminum Conductor Systems, call or write *Electric Service Works, Delta-Star Electric Division, H. K. Porter Company, Inc., Philadelphia 32, Penna.*

HKP ELECTRIC SERVICE WORKS
DELTA-STAR ELECTRIC DIVISION
H. K. PORTER COMPANY, INC.

HOW TO CONTROL ATMOSPHERES...



Entry end of #5 furnace at Vandergrift. Bailey instruments and controls safeguard atmospheres.

These Bailey Gas Analyzers monitor the atmosphere conditions in heating and cooling zones in the furnaces.

U. S. Steel uses BAILEY GAS ANALYZERS on continuous annealing line

At its Vandergrift, Pa., plant, U. S. Steel Corporation runs five lines for the continuous annealing of silicon strip steel used in making transformer and motor laminations. The furnaces are composed of a heating and cooling zone, each with its own protective atmosphere. Bailey Gas Analyzers are used to indicate that proper atmospheres are maintained for the protection of the product.

In starting up, furnaces must be thoroughly purged of all oxygen to prevent explosions. Bailey Oxygen Recorders determine completeness of purge before hazardous protective gas may be used. Bailey Combustibles Recorders are also used during purging as a check on the Oxygen Recorders. After purging, they analyze the incoming NX gas.

When operating, the furnaces are provided with the proper protective atmosphere composed of NX gas and dissociated ammonia. Bailey Hydrogen Recorders keep constant watch on the per cent hydrogen in the mixture. Bailey NX Gas and Dissociated Ammonia Flow Meters are used in regulating the total flow and composition of protective atmospheres.

As an additional safeguard, Bailey Furnace Pressure Recorders are used. These instruments control the protective gas flow to eliminate air infiltration into the furnaces.

Since 1948, when this Bailey equipment was installed, a perfect safety record has been maintained, yet purge time has been substantially reduced. Formerly purging was done on a time basis which was wasteful of gas and time. Steel quality has been uniformly high and high production has been maintained with the Bailey controls.

Whether your heat treating requires several huge continuous lines like these or one small batch-type furnace, Bailey Meter has the instruments and controls for you. See your Bailey Engineer or write to the Iron & Steel Division for additional information.

S11-1

BAILEY METER COMPANY

IRON AND STEEL DIV., 1047 IVANHOE ROAD, CLEVELAND 10, OHIO

In Canada — Bailey Meter Company Limited, Montreal

INSTRUMENTS AND CONTROLS FOR POWER AND PROCESS

BAILEY BUILDING BLOCK METHOD

Willimantic, Conn., went into production the week of June 3.

The new plant is a one-story, L-shaped building, containing approximately 90,000 sq ft of production and office space. The property on which the new plant is located was purchased by J&L in August, 1955, and construction of the building began early in 1956.

Hot-rolled bars will be rolled at the J&L mills in Pittsburgh and shipped to the new mill for cold drawing and processing into cold finished products. In the Willimantic process, J&L will be one of the first American steel companies to use Schumag continuous cold drawing machines. Coils of hot-rolled steel are fed into the machines, which draw, straighten, polish and cut to length in one continuous operation.

DONORA WORKS ADDS WIRE CLEANING LINE

▲ Another step in the present modernization program at Donora Steel & Wire Works of United States Steel Corp.'s American Steel & Wire Division has been accomplished with the installation of a 26,000-ton-per-month, straight-line cleaning house in the wire mill.

Up-to-date innovations that make this facility unique include: (1) the processing of 5000 lb of rods on each hanger, (2) use of a clock-card system for scheduling and recording production, (3) mechanical agitation of rods or wire while immersed in the acid solution, (4) use of twin heat exchangers to maintain a uniform temperature in each acid tank solution, (5) a central control room that meters predetermined amounts of acid and processing, supplies additions and maintains optimum operating temperatures in the various tanks, (6) continuous recirculation of lime solutions to maintain uniform processing results and (7) flash drying of coated rods in minutes rather than hours.

All operations related to the freeing of scale and other foreign matter from rods to be drawn into regular or copper-coated wire are performed in a new building 304 ft long, 39 ft wide and 28 ft high. High velocity exhaust fans, unit heaters and roof ports maintain comfortable working conditions by controlling the temperature, humidity and removal of acid fumes. In addition, two 5-ton capacity, gantry-type cleaning house cranes are equipped with forced-air fans to keep air circulating in the crane cabs.

INSTALLS NATURAL GAS ANNEALING FURNACES

▲ Detroit Steel Corp.'s Portsmouth, Ohio, plant has just put into operation six new 60-ton-capacity, natural gas, coil-annealing furnaces. This brings the total to 18 new furnaces and 48 bases added to heat treating capacity since Detroit's mill-wide modernization began four years ago. The new furnaces have been added to handle the company's increased output of flat-rolled products.

Used for bright annealing of cold-rolled strip 0.0239–0.089 in. thick and up to 48 in. wide, each furnace has an average processing rate of $2\frac{1}{4}$ tons per hour. The strip is processed in 68 in. O.D. coils. Four gas generators, each with a 6000 cfh rate, pro-

From first heat to heat treat . . .

LOFTUS

designs and builds them better

International Harvester Company, West Pullman Works

COVER TYPE ANNEALING FURNACES

DIRECT-FIRED SINGLE-STACK

Generally Recommended

for

Greater Productivity per Investment Dollar

and

Flexibility with Economy

When warrented by special conditions, radiant tube or multiple stack construction are also available.

LOFTUS

Engineering Corporation

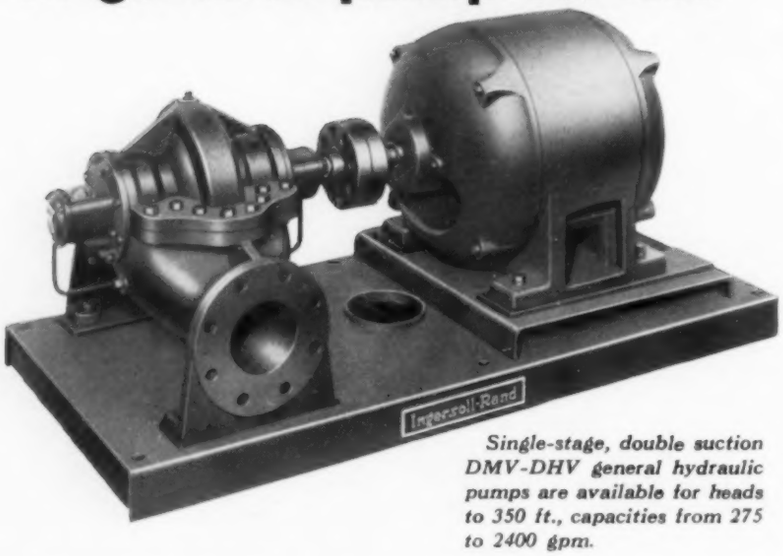
1 Gateway Center, Pittsburgh, Pa.

140 S. Dearborn St., Chicago. Ill.

57.12.4

ENDS MAINTENANCE

in general pump service



Single-stage, double suction DMV-DHV general hydraulic pumps are available for heads to 350 ft., capacities from 275 to 2400 gpm.

Double shaft seals and sealed ball bearings—standard equipment on **DMV— DHV** *pumps do away with stuffing box attention and bearing lubrication*

Now, with the DMV-DHV pump, you no longer have any stuffing box worries. There's no repacking! No annoying pump shaft leaks! The Double Mechanical Shaft Seals used are completely self-adjusting. They don't require attention throughout their entire service life.

Moreover, greasing or oiling of pump bearings is done away with. Modern Cartridge-Type Ball Bearings are employed—with the lubricant permanently sealed in. Here's another advanced feature that makes the DMV-DHV design the simplest, most maintenance-free pump ever developed by Ingersoll-Rand for general hydraulic service.

Greater Compactness is obtained with this modern construction using mechanical shaft seals and sealed bearings.

See your nearest Ingersoll-Rand representative for further information.

Ingersoll-Rand

10-290 Cameron Pump Division
11 Broadway, New York 4, N. Y.

PUMPS • CONDENSERS • TURBO-BLOWERS • COMPRESSORS • ROCK DRILLS
GAS & DIESEL ENGINES • AIR & ELECTRIC TOOLS

vide deoxidizing atmosphere for all 18 furnaces.

Total gas consumption for both the new and old installations averages 30,000 cfhr; the major portion of which fires the radiant tubes. Combustion air and gas are fed into the tubes at 2 psi.

Fans in the base of the circular furnaces assure even distribution of atmosphere and heat at the operational range of from 1310–1550 F.

Cooling the load of strip after completion of the annealing cycle is accomplished by both air and water. First, air is forced over the furnace bell by fans mounted on the top of the cooling bell. The air drops the temperature to 500 F, then a fine water spray from a serpentine coil within the bell is turned on to further reduce the temperature to 250 F, whereupon the coils are removed.

The new installation is adjacent to the first battery of 12 circular gas-fired furnaces installed four years ago. Although the first battery was set in a 10-ft pit in order to utilize a low existing overhead crane, the new installation is only slightly below floor level. To accommodate an overhead crane the roof over the new area was raised several feet. A 40,000-lb capacity tong is used to load and unload the strip. The crane travels from the heat treating area to the loading area in the same building where the strip is packaged and shipped.

All controls and recording instruments for the new battery of furnaces are contained in a small cinderblock room constructed adjacent to the furnace area. Here instruments connected with thermocouples in the furnaces continuously record and control furnace temperatures. From this single center, any combination of bases and furnaces can be connected, disconnected and regulated.

REFRACTORIES PLANT OPENED AT HAMMOND

▲ Basic Inc. has announced the completion of their distribution center at Hammond, Ind., to facilitate the supply of basic refractories to steel furnaces in the Chicago area.

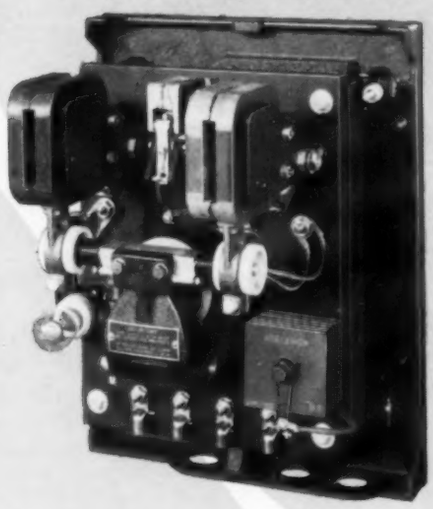
Material handling equipment at this new plant promises maximum flexibility in the variety of products stored as well as rapid turnover of all refractory materials. Bulk storage consists of eight self-cleaning

Ohio RD2 Controller (case not shown)

for better performance
it's Ohio Magnets—
especially when used with

OHIO MAGNET CONTROLLERS

Ohio RD1 Controller (case not shown)



Size for size, Ohio Magnets lift larger loads over longer periods—*particularly when used with Ohio Magnet Controllers.* For Ohio Magnet Controllers are of the high-efficiency, instantaneous-discharge type for any standard or special line voltage from 36 to 250 volts DC. Specify Ohio RD1 Controllers for 35-100 amps, Ohio RD2 Controllers for 75-150 amps—and get better magnet performance. Check Yellow Pages for your nearest Ohio Electric representative or contact Ohio plant for full information.

AA-3908

ohio ELECTRIC

Chester Bland
President

THE OHIO ELECTRIC MFG. CO.
5400 Dunham Road • Maple Heights • Cleveland, Ohio

Ohio Also Makes Separation Magnets
Nail Making Machines • Fractional
Horsepower, Shell and Torque Motors

The clocks keep ticking away. We need your dollars to make each minute count in the fight against cancer.

With $70, we can buy an eyepiece micrometer . . . $48 buys a laboratory flowmeter...$15 buys an instrument sterilizer . . . $3.75, a hematocrit reader.

Only you can decide how much you can afford to send. But send it *today*, to help us keep moving ahead in the struggle to save lives.

Send a generous check to "Cancer" c/o your local Post Office.

AMERICAN CANCER SOCIETY

bins with a combined capacity of 1000 tons, while the adjacent warehouse accommodates 250 tons of bagged refractory products. Rapid-loading equipment for rail as well as truck shipments is now in operation.

RAVENSWOOD MILLS NOW IN OPERATION

▲ Aluminum foil is now being rolled on high-speed mills at Kaiser Aluminum & Chemical Corp.'s Ravenswood, W. Va., plant.

The foil is being rolled on two new 60-in. mills at speeds up to 3000 fpm in strips as wide as 56 in. at different gages.

Two other mills, including a 72-in. mill designed to roll metal at speeds as high as 4500 fpm in widths up to 66 in., are being installed and this equipment will be in operation by early 1958. In addition to their high operating capacity, the new mills are designed to permit rapid changeover to light gage sheet rolling.

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone*. Ask our engineers to help you solve your specific problems.

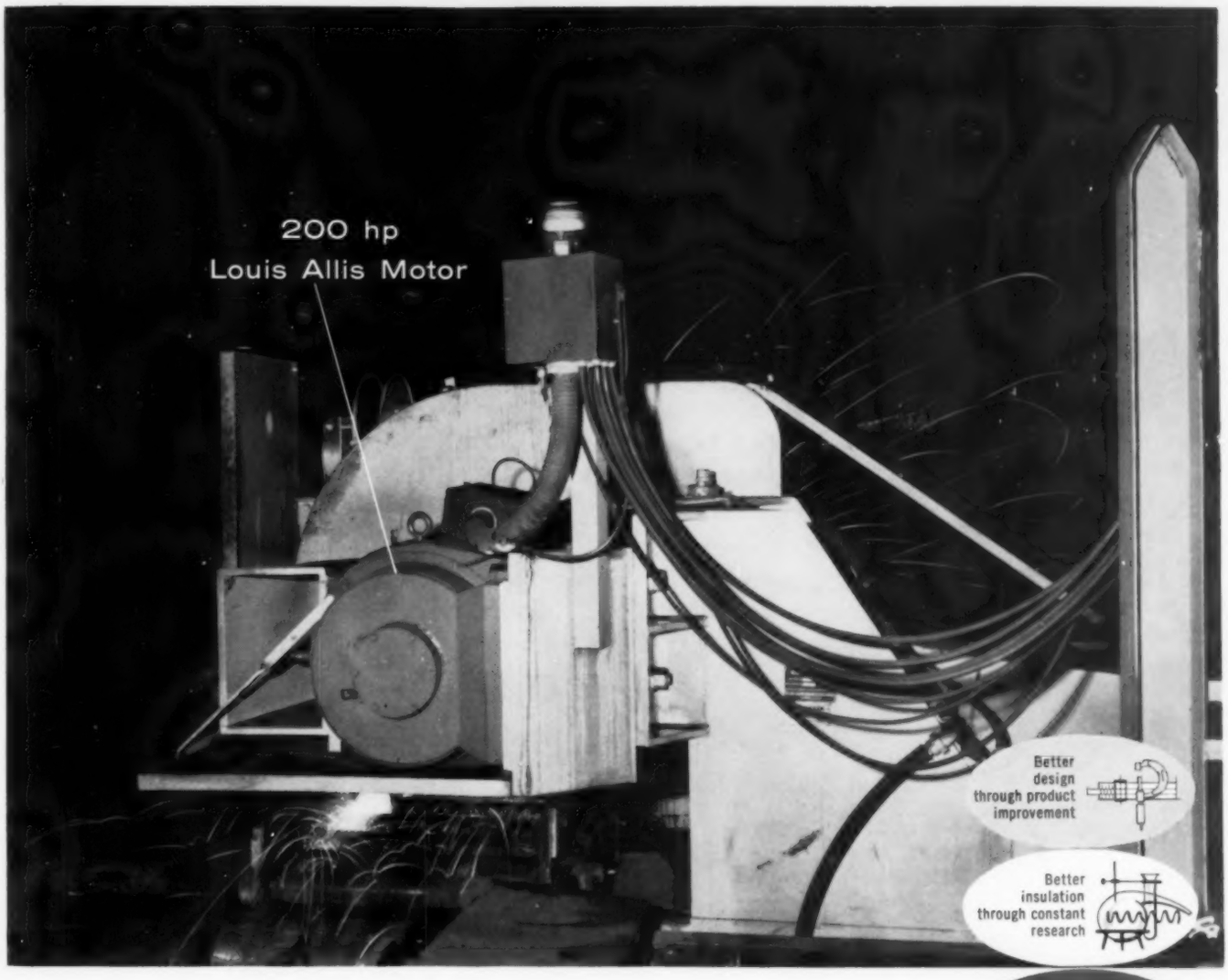
- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A·B·K

LAMINATED PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

American Brake Shoe — American Brakeblok Division
DETROIT 9, MICHIGAN



Eases toothless saw through toughest steel in seconds

Louis Allis motor powers high-speed steel cutter

Powered by a Louis Allis 200-hp high-torque squirrel cage motor, the friction saw shown above zips through steel like a hot knife through butter. The blade-edge, traveling at more than 300 miles per hour, generates enough frictional heat at the point of contact to actually *melt* its way through an 8 in. steel pipe section in 3.25 seconds — a 100 lb. rail in 4 seconds — a 12 in. I-beam in 5.7 seconds.

These extremely high cutting rates and the hydraulic carriage drives of these machines require high torques subjecting the motors to severe loading conditions. That's why the manufacturer of this heavy-duty friction saw selected Louis Allis motors for dependable power supply to blade and carriage drives.

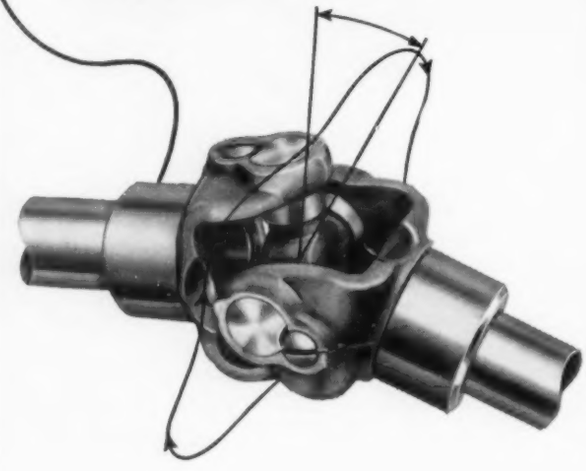
Whether it's for cutting steel or for any other demanding application, Louis Allis can provide the motor you need. Our engineers will help you select the exact rating, speed, and enclosure your job requires. What's more, they can recommend electrical and mechanical modifications that may improve your operation, reduce costs, and provide long, trouble-free motor life.

For facts or engineering assistance, contact your nearby Louis Allis District Office. Or write The Louis Allis Co., 450 E. Stewart St., Milwaukee 1, Wis.

LOUIS ALLIS

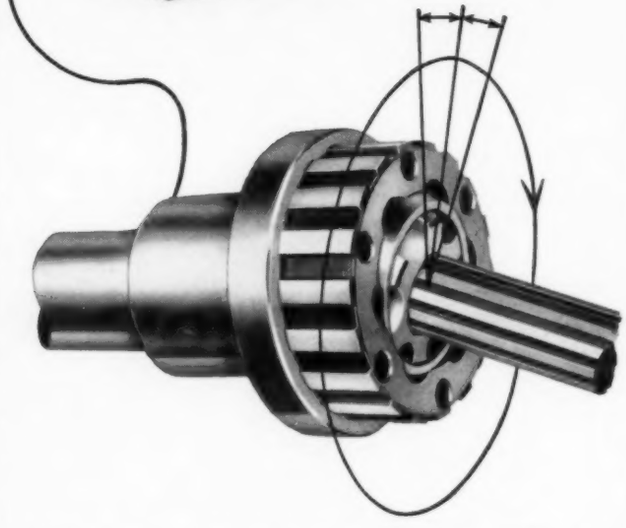
MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

THIS ACTION MAY HAVE A LOWER PRICE



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*

THIS ACTION ALWAYS HAS A LOWER COST



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

RZEPPA

SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company

3929 CHRISTOPHER, DETROIT 11, MICHIGAN

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

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JUNE, 1957

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Note: Post cards expire three months after publication date.

(1) Automatic-Positioning Screwdown Control

The latest developments in automatic positioning screwdown control are discussed in a reprint by A. C. Dyer, Steel Mill Consultant, Electric Controller & Mfg. Co., Division Square D Co. The article describes two methods of scheduling roll positions. One is by slider-contact panels and the other by the punched card system, in which a card punched with holes represents a complete rolling schedule. The article also contains illustrations of the controls at work.

(2) Centrifugal Castings

Electro-Alloys Division, American Brake Shoe Co., has issued a bulletin describing their facilities and capacities for centrifugal castings. Properties of the four most common grades of centrifugally cast tubes are listed in chart form, and a chart on the weights of tubing per in. of length is included. Illustrations of the typical centrifugal castings in Thermalloy is also pictured.

(3) Mortar Manual

Published by the Universal Atlas Cement Co., is a booklet entitled, "Lumnite Cement Mortar Manual —Gun Applied Linings—Masonry." The new manual contains complete information on mortar preparation, placing procedure and general instructions for gun-applied linings in oil refineries, power plants, metal and similar industries. An appendix contains information on selected aggregates, thermal conductivities of Lumnite concretes and strength curves. A bibliography on refractory concrete has been included for easy reference.

(4) Cutting Knives

Cleveland Knife Division, The Hill Acme Co., has released a booklet covering the types, sizes and grades of metal cutting knives best suited to all types of metal shearing. Slitters, squaring blades, alligator and bar knives are just a few of the many types described. Care and handling, best cutting practice and recommended grades for various operations are included with specifications.

(5) Lubricating System

The Farval Corp., has published a booklet describing their new type of circulating oil system. The booklet explains the operating sequence of this system, and contains cut-away drawings of their dualine valves. Also described in the system are a variable delivery pumping unit, a high-low pressure switch, and a high pressure twin filter. (Bulletin No. 70)

(6) Crane Cab Coolers

Air conditioners for crane cabs and pulpits are described in a bulletin published by Larco, Inc. The bulletin illustrates and describes models of aire-rectifiers for each temperature range and size of overhead crane cab. It also shows models—both water cooled and air cooled—for each size of pulpit. Featured is the new 2-Stage aire-rectifier for 180 to 230 F ambient at the cab. Also displayed is a line of fully insulated crane cabs for existing cranes. (Bulletin AC-573)

(7) Valves

Golden-Anderson Valve Specialty Co., has published a bulletin entitled, "Valves for Automation in the Steel Mills." The bulletin schematically shows various piping and valve arrangements for particular applications, such as supply water from source to mill; emergency fire protection; spray valves for hot strip mills; coke quenching and drain valves; preventing flywheel explosion; and other mill uses. (Bulletin SM-1)

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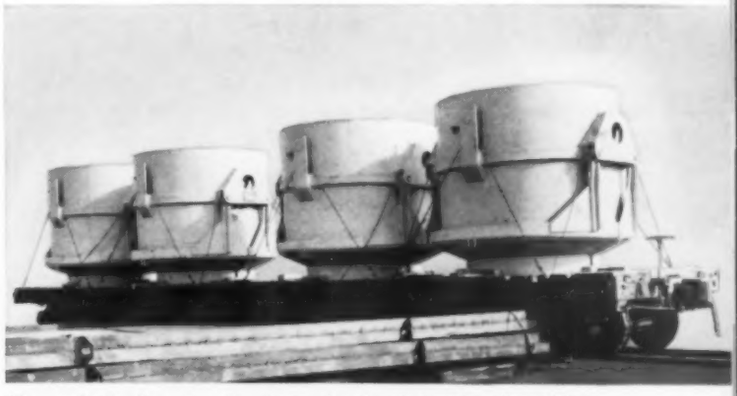
STEEL PLATE *Fabricating Facts!*

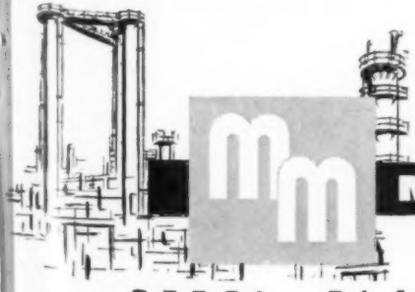
McGREGOR-MICHIGAN Brochure Describes Diversified Facilities and Production

In this compact 12-page brochure you'll find valuable information on McGregor-Michigan's equipment and typical steel plate fabrications. It shows scenes in our new 30,000 square foot Heavy Fabricating Plant and our original Rivard plant. It describes some of our new equipment including a 650 ton press brake and our 600 ton "Bulldozer" horizontal forming press capable of forming heavy beams or solid sections. In addition you'll find clear illustrations of steel plate fabrications for the primary metal producers—ladles, buckets, hooks, doors, water-cooled roof rings and others—and equally interesting chemical and petroleum processing equipment—ASME Code vessels, autoclaves, heat exchangers, kettles and tanks. Many of these assemblies run to 50 tons and over, in mild, stainless and alloy steels. Typical miscellaneous industrial fabrications shown are engine beds, bases for machines, jigs and fixtures, heavy-wall cylinders, foundry cupola shells, furnace casings, a self-propelled sewer tunnel shield and a heavy boom for a power shovel. The brochure also describes our plate warehousing and specialized surface treating services.

We would appreciate your including this informative booklet in your file of fabricating sources. Please send for a copy and the name of our representative nearest you or call direct for prompt service on any steel plate fabricating problem.



Clam shell charging buckets destined for leading West Virginia aluminum plant.



SINCE 1841

McGREGOR-MICHIGAN CORPORATION

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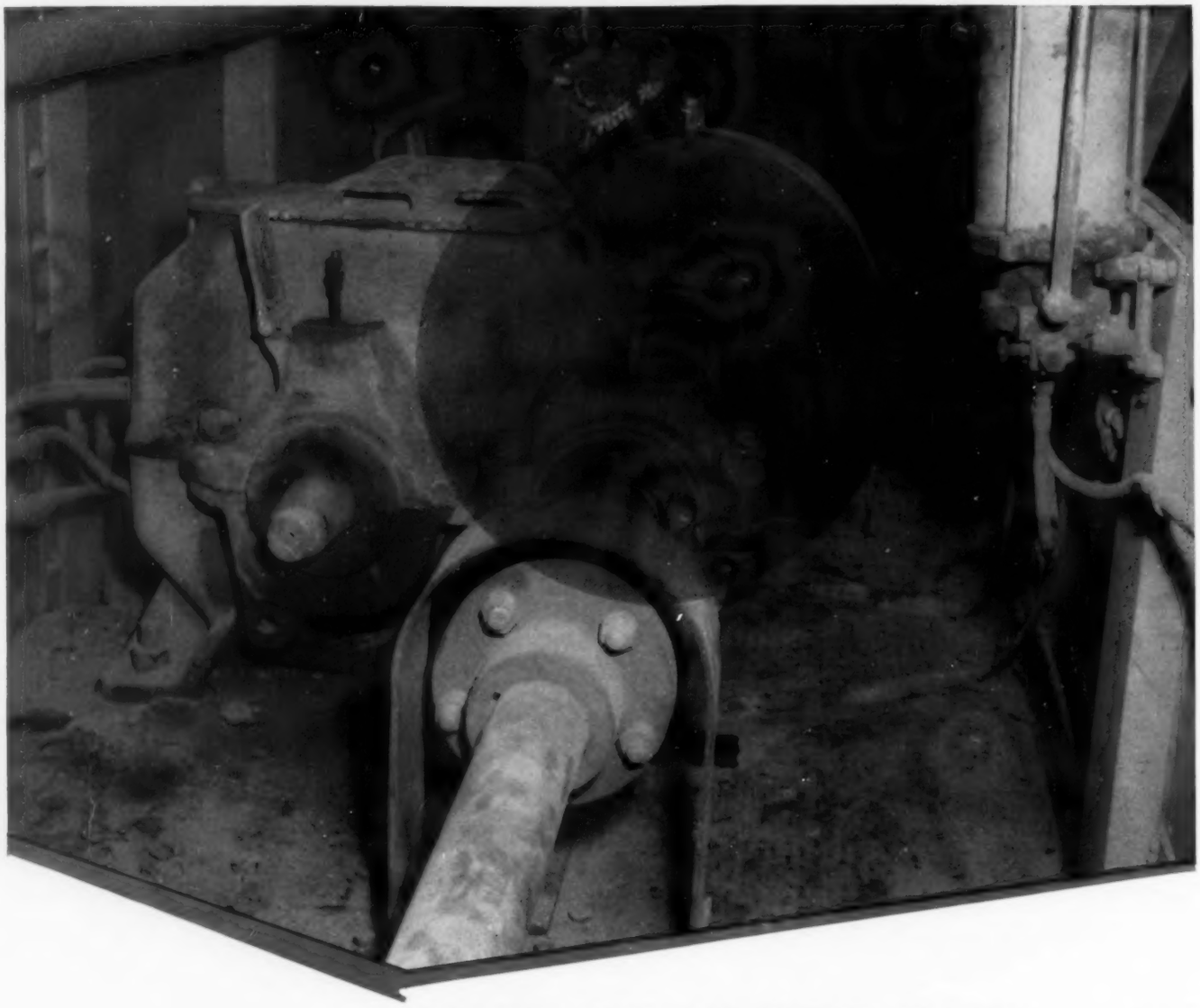
STEEL PLATE FABRICATING AND WAREHOUSING



OVER 20 YEARS OLD . . . yet Bearings, Inc. delivered replacement bearings for these back axles from stock

Our steel mill customer had torn down the motors on his 160 ton open hearth ladle crane for a complete overhaul. These motors were equipped with back axles mounted on roller bearings which had to be replaced.

Our bearing engineer was called when the customer couldn't identify the bearings or the outer races. Our engineer quickly determined that the roller assembly was a standard size and make. He also found that the outer race was a special we had recently supplied another company through a custom manufacturing source.

One pair of these special outer races was still in stock and was delivered immediately with the bearing! The complete order for several pairs was filled within a short time.

This customer now knows what we mean when we promise service! He didn't have too much hope of replacing this assembly from the bearing manufacturer—and finding a complete set in a local stock was not even considered!

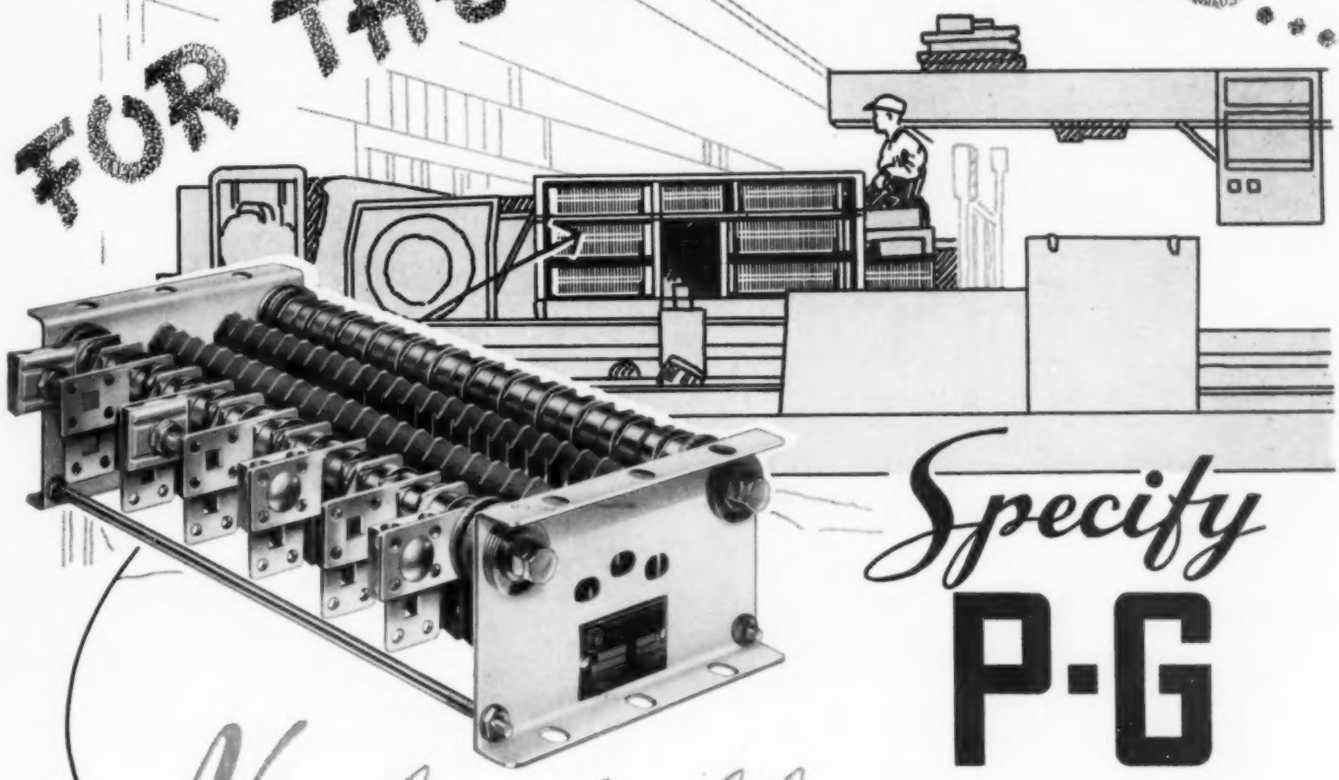
You can get to know this kind of service for all nationally known bearings and bearing accessories if you will call the branch nearest you!

Providing bearing service in the territories adjacent to our branches, listed below.

BEARINGS, INC.

OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Mansfield • Toledo • Youngstown • Zanesville
INDIANA: Ft. Wayne • Indianapolis • Muncie • Terre Haute
PENNSYLVANIA: Erie • Johnstown • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Wheeling
NEW JERSEY: Camden • **MARYLAND:** Baltimore
DELAWARE: Wilmington •
Subsidiaries: Balanrol Corp. • Buffalo, N.Y.•
Kentucky Ball and Roller Bearing Co. • Louisville, Ky.

FOR THE TOUGH JOB...



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P-G has BOTH!

STANDARD Resistors

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Write for Bulletins

Built of steel and mica, there is nothing delicate or fragile about a P-G Resistor. When used for the troublesome jobs that seem to plague every maintenance department, continuous Trouble-Free Service may be expected.

P-G Resistors are not affected by vibration set up by various kinds of mobile steel mill equipment. Neither are they harmed by moisture laden or corrosive atmospheres. In addition there is provision for expansion coupled with adequate ventilation to dissipate the heat of operation.

When buying Resistors . . . try P-G the ORIGINAL Steel Grid Resistor next time on your toughest job, they are rugged and dependable.

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

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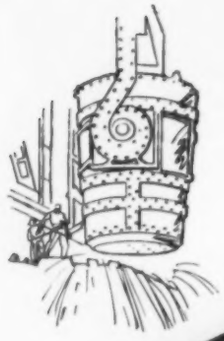

Eichleay Installations

for

McLouth Steel

Dismantled an existing Steckel Mill and prepared the various pieces for export shipment. Also to make space available for a new continuous mill, mechanically installed the new Hot Strip Mill with all pertinent auxiliaries. The work was performed at the Trenton, Michigan plant.

On the Cold Mill Program at Gibraltar, Michigan, a Tandem Cold Mill with auxiliaries was mechanically installed, along with other major equipment such as temper mills and shearing lines.

Work of this type requires specialized services in the mechanical erection field and they are offered to the industry by the Eichleay Corporation, whose practical experience and engineering background enable them to perform installation work in heavy industry in the most economical manner.

EICHLEAY SERVICES

- **Industrial Installations**
- **Construction of Heavy Foundations**
- **Building and Machinery Moving**
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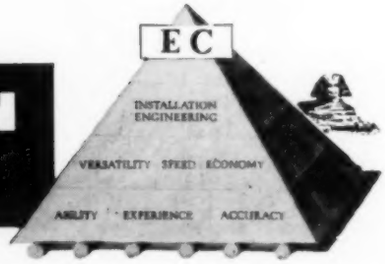
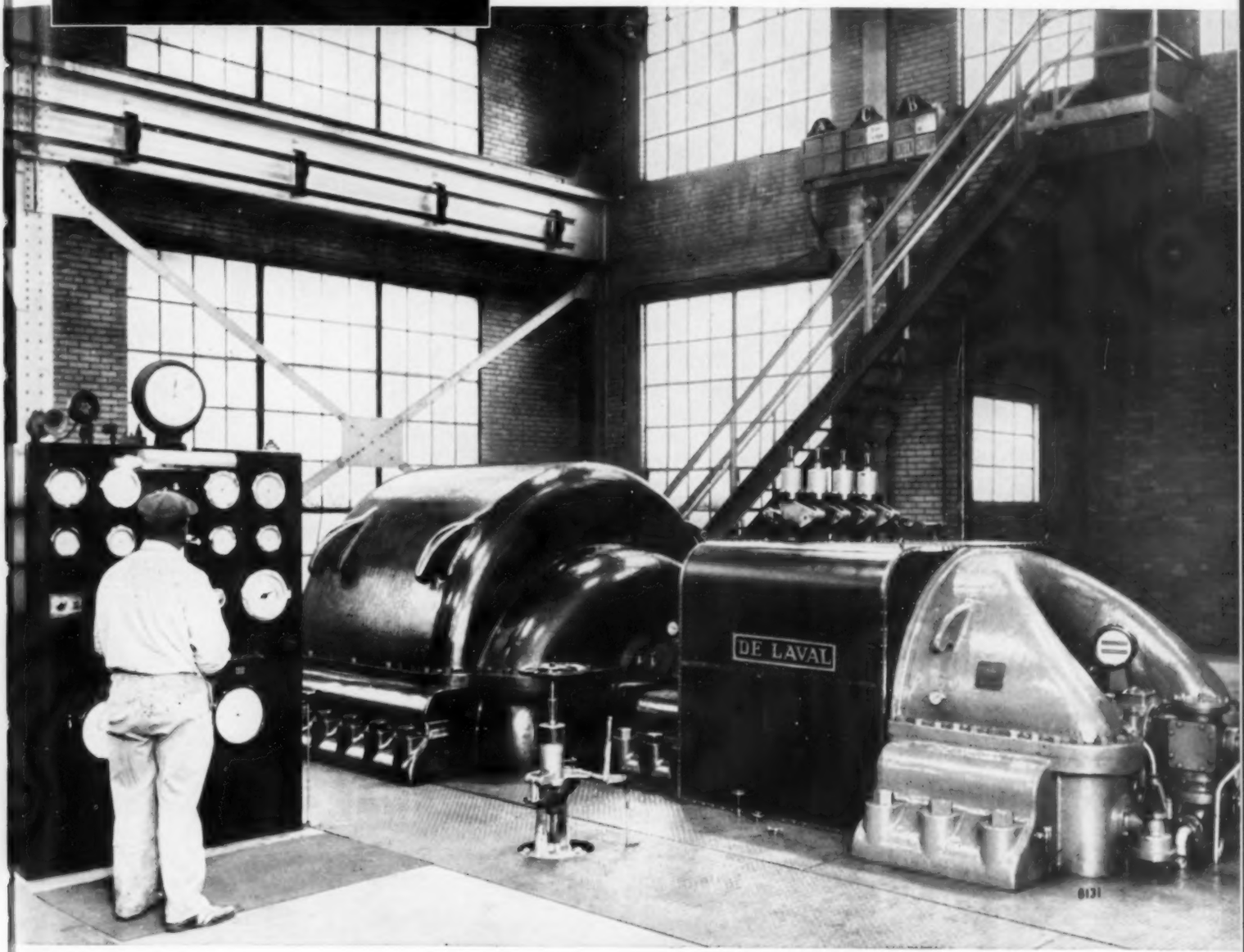


DE LAVAL
BLAST FURNACE BLOWERS

give 20 years of service at Great Lakes Steel Corp.



Shown is one of two De Laval centrifugal blast furnace blowers at the Ecorse, Michigan, plant of the Great Lakes Steel Corporation, Division of National Steel Corporation. This 85,000 cfm unit was installed twenty years ago; another 75,000 cfm unit went on the line a year earlier. Both have given dependable round-the-clock service ever since. These turbine-driven blowers are hooked up to a multi-head which enables either one to be used in conjunction with any of the three blast furnaces.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

Send for Bulletin 0504

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DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

Morgan Quality in Action

MORGAN WORCESTER

High Speed Four Strand Rod Mill

Cuyahoga Works, American Steel and Wire Division
UNITED STATES STEEL CORPORATION

Morgan Mills are known to steel men throughout the world for their sound design and accurate manufacture . . . an enviable reputation which has assured mill users of efficient and trouble-free operation. Morgan Mills have kept pace with the ever-increasing demands for high output and greater accuracy of product.

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WORCESTER, MASSACHUSETTS
ROLLING MILLS MORGOIL BEARINGS GAS PRODUCERS
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Personnel News...

Charles H. Good, Jr., was named assistant to vice president, operations—steel, U. S. Steel Corp. In his new position, Mr. Good will have the responsibility of maintenance planning. He started his career with U. S. Steel in 1939 at Duquesne Works as an engineer of tests in the utilities department. In 1944 he was made assistant superintendent of the utilities department and in 1948 assistant superintendent-assigned and operating maintenance, becoming superintendent of that department in 1950. On March 1, 1951, he was made assistant superintendent of maintenance division at Duquesne and in 1953 he became assistant to general superintendent. In 1955 he was promoted to chief engineer of the Duquesne Works, the position he held until his recent appointment. **Jesse D. Marino** succeeds Mr. Good as chief engineer at Duquesne. He began his career with U. S. Steel in 1940 at the Irvin Works in the electrical engineering department. He later became assistant maintenance foreman at the plant. In 1946 he was transferred to the Duquesne Works as an electrical engineer and in 1948 became general supervisor-design for the engineering department. In 1950 he became Works engineer at Duquesne and five years later was promoted to assistant chief engineer, the position he held until his recent appointment.

Herbert A. Long has been promoted to general manager of operations, Pittsburgh Steel Co. Mr. Long, chief engineer since 1954, succeeds **Carl E. Breuer** who was elected vice president—operations, on April 10. Succeeding Mr. Long as chief engineer will be **John C. Peth, Sr.** He has been Pittsburgh Steel's chief electrical engineer for the past seven of his 34 years with the company. Mr. Peth's successor is **Elmer E. Barthel,** formerly assistant chief electrical engineer.

Mr. Long joined Pittsburgh Steel in 1926, as an inspector in the Allenport Tube Division. Later, he became a draftsman in the Monessen Engineering Department. In 1935, he became plant engineer of the Allenport Works and chief engineer of that works in 1944. He left that post to become chief engineer for the company. Mr. Peth joined a Pittsburgh consulting engineering firm in 1920. For the next two years, he was assigned to the firm's electrical design work on Nos. 3 and 4 tube mills at Allenport. In 1922, Mr. Peth joined Pittsburgh Steel as assistant electrical engineer. Mr. Barthel's employment at Pittsburgh Steel followed his assignment as an outside contractor's project engineer during installation of the new sheet mills at Allenport Works.

Don S. Holstein was appointed manager of Armco Steel Corp.'s Middletown Works, succeeding **G. D. Tranter,** who retired from active service after 46 years with Armco, and six years as manager of the Middletown plant to become a consultant to the company. Mr. Holstein began working part time at Armco during school vacations from 1918 to 1921, and joined the company full time as an inspector helper in 1922. He moved to the blooming and bar mill later that year and in 1928 became a turn foreman on the strip mill at the Middletown Works. In 1932, he was made a turn foreman of the blooming, bar and strip mill, and the following year became a roller. In 1936, he was made general foreman of the department and became superintendent in 1937. Mr. Holstein was appointed assistant general superintendent at Middletown in 1944, and became general superintendent in charge of all rolling and processing operations in 1951. In 1956 he was named assistant manager of the plant. Mr. Tranter spent his entire 46-year career with Armco at the Middletown Works. He joined the company in 1911 as a stocker weighmaster in the open hearth department, and after serving as a switchman, became a stocker boss in 1914. In 1916, he became an assistant superintendent in the open hearth, and served as superintendent from 1923 to 1930. In that year he was made general superintendent of the Middletown plant. In 1935, he spent several months in Europe on special assignment for the Armco International Corp. Mr. Tranter was appointed manager of the Middletown Works in 1951.

J. A. W. Iglehart and **M. K. Schnurr** have been elected to the board of directors of Jones & Laughlin Steel Corp. They were the chairman of the board of directors and the president, respectively, of Rotary Electric Steel Co. for many years prior to the transfer of all the assets and business of that company to Jones & Laughlin on April 30, 1957. Mr. Iglehart is a partner of W. E. Hutton & Co., and Mr. Schnurr is the president

C. H. GOOD, JR.

J. D. MARINO

H. A. LONG

D. S. HOLSTEIN

E. V. AKERLOW

R. P. HINDMAN

W. R. GEALEY

L. G. GREENERT

of the Stainless Steel Division of the corporation. **C. L. Austin** has resigned from his offices with the corporation. He will be a consultant to the president until the end of the current year, at which time he will retire from active service with the corporation.

Earl V. Akerlow has been promoted to division manager, Engineering Department, Kaiser Engineers. Mr. Akerlow has specialized in steel plant design and engineering since 1941 when he originally joined the Kaiser organization as a design engineer. In his new capacity, he will be responsible for the engineering of the major portion of work being performed by Kaiser Engineers in connection with the $194,000,000 steel plant expansion program for Kaiser Steel Corp. at Fontana, Calif.

Robert P. Hindman and **William R. Gealey** have been named assistant general superintendents at the Butler, Pa., Works of Armco Steel Corp., and **Leroy G. Greenert** has been appointed superintendent of the rolling department at Butler. Mr. Hindman will direct the traffic, scheduling, metallurgical, inspection, and shipping departments. He joined Armco's Butler Works in 1933 as an analyst in the chemical laboratory. In 1939, he was appointed assistant works metallurgist, and became works metallurgist in 1949. He was made assistant to the general superintendent in 1955, and held that position until his recent promotion. Mr. Gealey, who will supervise the rolling departments and the wheel works department, also joined Armco in 1933. He entered the industrial engineering department and was serving as a senior time study man when he was made slab mill maintenance foreman in 1938. He was promoted to assistant superintendent of the slab mill department in 1946, and to assistant superintendent of the rolling department in 1951. He was superintendent of the rolling department in 1951. Mr. Greenert also joined the Butler Works in 1933. He advanced through the cold mill department and was made turn foreman in 1946. He was appointed general foreman of the cold mill department in 1951, and held that position until his present advancement.

Dr. James B. Austin has been appointed vice president—research and technology of United States Steel Corp. Dr. Austin was associated with the research laboratory of the corporation in Kearny, N. J., from its establishment late in 1928 until it was moved to U. S. Steel's Research Center in Monroeville, Pa., in 1956. For the first 12 years he was with the laboratory in Kearny, he was engaged as a physical chemist. He became supervisor of chemistry in 1941 and assistant director of the laboratory in 1944. Two years later he became director of research and was appointed assistant vice president—research and technology of U. S. Steel in 1954. He moved his office to Pittsburgh in 1956 when he was made vice president—fundamental research, the position he held at the time of his present appointment.

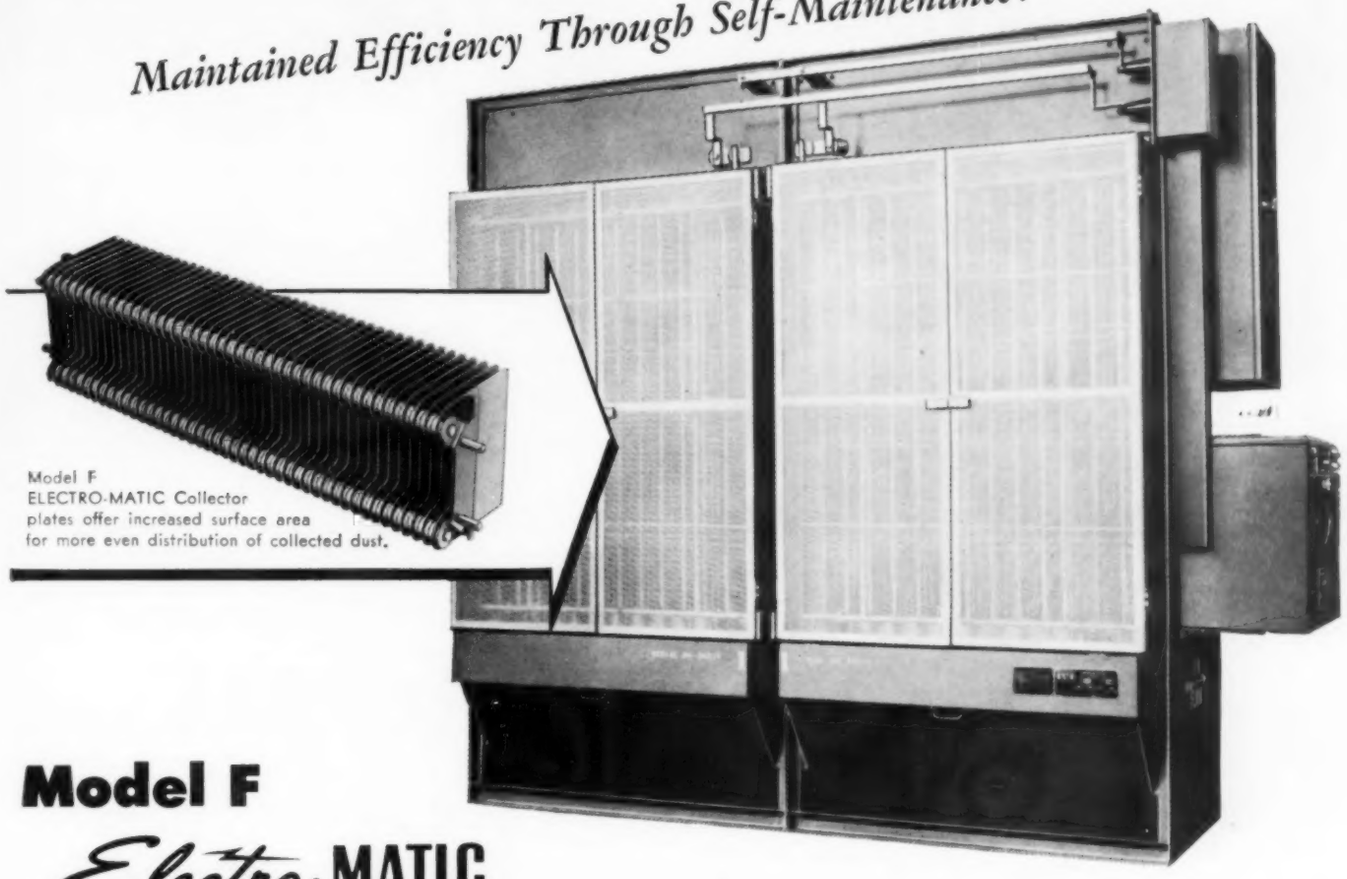
Harry L. McFeaters was elected vice president—engineering of the Pennsylvania Engineering Corp. Mr. McFeaters has been chief engineer since 1939. Prior to joining the company in 1929 he was associated with Goodyear Tire and Rubber Co., Pressed Steel Car Co., and Dravo Corp.

Victor E. Holtslander has been made assistant superintendent electrical department, Inland Steel Co., Indiana Harbor Works. Mr. Holtslander was formerly general electric shop foreman.

Edgar G. Platt has been appointed to the newly created post of general works manager, Refractories Division, H. K. Porter Co., Inc. He will supervise the operation of the division's nineteen plants. Mr. Platt was formerly works manager for Porter's McLain Fire Brick Division, and was with McLain since 1923.

John H. Chiles, Jr., manager of the transformer division at Sharon, Pa., and **B. M. Brown,** manager of the Baltimore, Md., Divisions, have been elected vice presidents of the Westinghouse Electric Corp. Mr. Chiles has spent his entire career with Westinghouse at the transformer division. He became engineer in charge of the instrument transformer section in 1934, division engineer in charge of instrument and regulator activities in 1943, and engineering manager for the entire division in 1949. Mr. Brown joined Westinghouse in the machinery electrification section at East Pittsburgh, and in 1944 was appointed manager of the industrial department's petroleum and chemical section. In 1948 he was

Maintained Efficiency Through Self-Maintenance!



Model F
ELECTRO-MATIC Collector
plates offer increased surface area
for more even distribution of collected dust.

Model F
Electro-MATIC
Delivers Uniformly Clean Air, Continuously, Around the Clock

WANT a continuity of clean air that won't vary in quality from one day, month or year to another? It's yours with the Model F ELECTRO-MATIC—the new electronic precipitator whose continuous high efficiency is assured through constant self-cleaning.

The cleaning efficiency of the Model F ELECTRO-MATIC extends over a wide range of particle sizes, from smoke to largest air-borne materials. Its "capacity for work" is increased, too. Newly designed collector plates increase surface area 53% to further reduce possibility of dust build-up and, at the same time, slows down air velocity between plates by 25%.

But here's the payoff! Unlike most other filters, ELECTRO-MATIC's efficiency can't taper off due to the accumulation of dust. Continuous self-cleaning action keeps collector plates in constant fighting trim. There's no time out for washing down with hot water. No need for extra sewer or water connections. ELECTRO-MATIC maintains its own rigid housekeeping schedule without regard to clock or calendar.

Yes, if performance is the payoff, the Model F ELECTRO-MATIC is definitely today's finest electronic filter. For complete product information, call your local American Air Filter representative, or write for Bulletin 250.

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BETTER AIR IS OUR BUSINESS

Unit Heaters Herman Nelson

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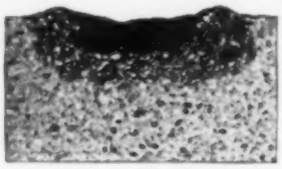
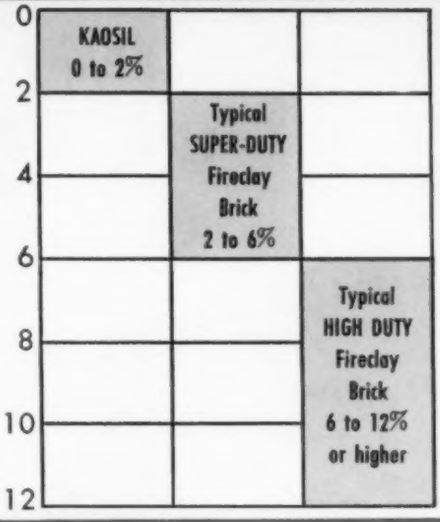
on high duty Fireclay Brick



and on KAOSIL

LINEAR SUBSIDENCE in the standard load test for SUPER-DUTY Fireclay Brick Load 25 lb./sq. in. Temperature 2640°F.



These illustrations show why Harbison-Walker KAOSIL excels for many furnace requirements in iron and steel plants

THE remarkable resistance of KAOSIL to corrosion in atmospheres containing volatile alkalies, contributes greatly to its successful use in Blast Furnace Stoves. The photographs above show the results of five hour cup tests with sodium carbonate at 2550°F. While some erosion occurred with both brick, there was a great difference in the degree of penetration. The aluminous High Duty fireclay brick was deeply penetrated and corroded, while KAOSIL was not penetrated beyond the zone of erosion and the cup still held the glass.

Among applications for which KAOSIL is especially suited are: *Blast Furnace Stoves*—combustion wells, domes, checkers; *Soaking Pits*—sidewalls, regenerator arches, top courses of checker chamber walls, and covers; *Open Hearths*—fantail roof, regenerator roof, side walls above checkers, checker arches; *Heating Furnaces*—suspended or sprung arch roofs, walls; *Hot Metal Mixers*—above metal line; *Miscellaneous*—piers under load in soaking heats—in heavily insulated arches and walls—arches of unusually wide span.

a SEMI-SILICA fireclay refractory of *superior* quality

1. Kaosil is made with hard-fired siliceous kaolin of exceptional purity. (Silica 75 to 76%—extremely low alkali content—less than 1%).
2. Kaosil is formed by the power-press method which provides uniform texture, free from laminations—and assures superior workmanship.
3. Kaosil remains rigid and does not become pyroplastic nor shrink in soaking heats up to its temperature limit.
4. The temperature of incipient vitrification of Kaosil is higher than that of the best aluminous high duty fireclay brick. This property contributes to its excellent spalling resistance.
5. In atmospheres containing volatile alkalies at high temperatures, Kaosil becomes glazed and penetration is thereby greatly retarded.

HARBISON-WALKER REFRACTORIES COMPANY
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World's Most Complete Refractories Service
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named manager of transportation, aviation and marine sales. He was appointed manager of the airport plant at Baltimore in 1953.

Warner Kenyon has been named assistant works engineer in charge of operations and **Lars R. Larson,** assistant works engineer in charge of development and construction at Ashland Works of Armco Steel Corp. Mr. Kenyon joined Armco in 1936, as an engineering draftsman. He was promoted to mechanical engineer in 1945 and chief draftsman in 1950. Mr. Larson became associated with Armco in 1946 as an engineering draftsman in general engineering. He was promoted successively to mechanical engineer, senior mechanical engineer and project engineer. In recent months, he has served as project engineer for the Ashland Works construction program.

George H. Acker was elected president of the Cleveland Worm & Gear Co. and its affiliate, The Farval Corp. At the same time, **Howard Dingle** was named chairman of the board of both companies. Before his election to the presidency, Mr. Acker held the post of executive vice president and Mr. Dingle was president. Mr. Dingle joined the organization as vice president and general manager and has served as president since 1927. Mr. Acker became associated with Cleveland Worm in 1923 and was named chief engineer in 1925. He was appointed vice president in charge of engineering and production in 1942 and became executive vice president in 1952.

John N. Miller has been named vice president—general operations of Jessop Steel Co. and its subsidiaries. At the same time **Harry K. Taylor** was promoted to vice president—operations of Jessop's headquarters plant at Washington, Pa. Mr. Miller was formerly assistant to the president of Jessop, a position he has held since joining the company in 1955. He had been with Universal-Cyclops Steel Corp. for 25 years and was general manager of production. Mr. Taylor moves up from a position as assistant vice president—operations. He joined Jessop in 1944 and became production manager of the Composite Steel Division a year later. In 1948 he was promoted to manager of the division and three years ago was named assistant vice president—operations.

Clarence M. Stevens has been named manager of manufacturing for the General Electric Co.'s Industrial Heating Department at Shelbyville, Ind. Mr. Stevens succeeds **Karl D. Kirk,** who has been named to the manufacturing staff of the company's Medium A-C Motor & Generator Department, with headquarters in Schenectady, N. Y. Mr. Stevens joined General Electric in 1942. After assignments in various company components, he became assistant production manager of the Large Motor & Generator Department in 1949. The next year Mr. Stevens was appointed assistant superintendent of manufacturing for the department, and in 1953 he became manager of manufacturing engineering for that department, the position he has held until the present time.

William M. Bailey has retired as president of the William M. Bailey Co. and has been elected to the newly established post of chairman of the board of directors. **Eugene M. Neely,** formerly manager of sales, succeeds Mr. Bailey as president. **J. Russell Miller** becomes the new manager of sales. Mr. Bailey established the company in 1921, and has directed its operation since then.

Thomas K. Piper was appointed engineering manager of the newly opened Pittsburgh Branch engineering office of the Atlas Mineral Products Co. Before joining Atlas, Mr. Piper spent 15 years with United States Steel Corp. in mill maintenance and engineering. For the last six years, he has served as vice president and general manager of the Chemsteel Construction Co., Inc. The Pittsburgh district sales office will continue to be under the direction of **C. P. Burns.**

W. E. Steinwedell, one of the founders of The Gas Machinery Co. in 1902, is retiring from active service after 55 years on the board. He has been named honorary chairman of the board and remains a consultant to the company.

Dr. Dimitri Kececioglu was appointed assistant to the director of mechanical engineering of Allis-Chalmers Manufacturing Co.'s Industries Group. Dr. Kececioglu joined Allis-Chalmers in 1952 as a research engineer and for the last several years had been engineering scientist-in-charge, mechanical laboratory, Research Division.

WARNER KENYON

L. R. LARSON

G. H. ACKER

HOWARD DINGLE

O. H. McCLEARY

L. T. SYLVESTER

G. D. LAWRENCE

I. W. EVANS

Odd H. McCleary was elected president of Mathews Conveyer Co. **L. T. Sylvester,** who has served as president of Mathews since 1952, was elected chairman of the board of directors.

George D. Lawrence has been appointed chief engineer—electric furnaces for U. S. Steel Corp.'s American Bridge Division. He began with American Bridge in 1948 as an electrical engineer at Ambridge. In 1950, Mr. Lawrence was made assistant contracting manager—electric furnaces, the position he held at the time of his latest promotion.

I. W. Evans has been named chief engineer—cranes of The Morgan Engineering Co. Mr. Evans was formerly welding and development engineer.

F. A. Sarcone has joined Patterson-Emerson-Comstock, Inc., in the company's engineering division. He was previously with Hall Laboratories and Infilco, Inc. Prior to that Mr. Sarcone spent five years with Crucible Steel.

H. Follett Hodgkins, Jr., was appointed assistant general manager of Rollway Bearing Co., Inc. Mr. Hodgkins joined Rollway six years ago. A member of the board of directors, he served in the company's time-study and methods department, later as assistant superintendent of the manufacturing department. In his new capacity, he will assist in the overall supervision of Rollway's three Syracuse plants.

Max E. Bills has been made division superintendent, sheet and tin mill at U. S. Steel Corp. Gary, Ind. He succeeds **Glenn P. Carson,** now assistant general superintendent at the Irvin Works, Dravosburg, Pa.

Thomas W. Metz has been appointed manager of the Mid-Atlantic Region of Allis-Chalmers Industries Group succeeding **Frank R. Freyler,** who died recently. Mr. Metz, who came to Allis-Chalmers in 1938, had

New marking head allows cut letters and ingot numbers to be changed instantly from the operator's pulpit. Wide versatility for stamping ends of blooms, slabs, and billets. *Write for Bulletin 613-D on new Billet Marker.*

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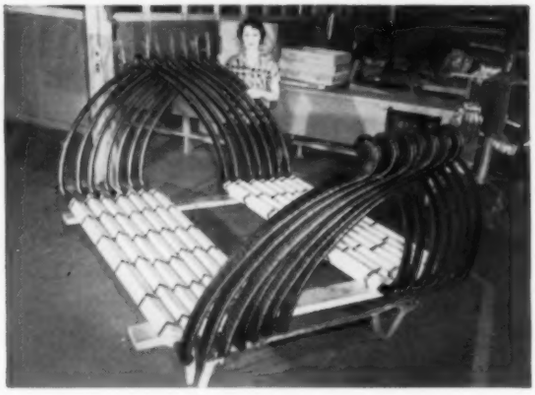
National Replacement Coils

Help Keep Vital Motors and Generators on the Job . . .

. . . IN THE ELECTRIC POWER INDUSTRY

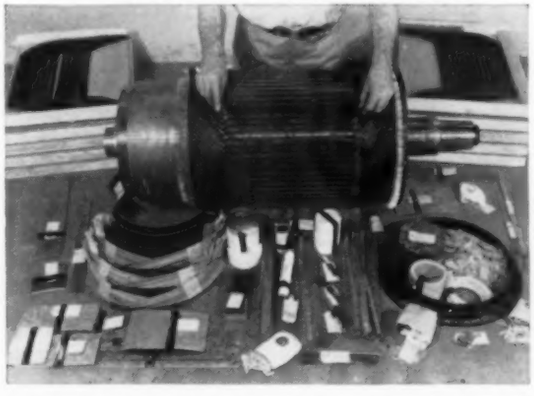


The photo shows part of a set of 54 stator coils for a large AC turbo generator. Rewinding equipment of this size is normally done on the job site. National can furnish the coils and send a full winding crew (or supervisory personnel with the customer supplying the labor), or National can supply the coils only (with the customer handling the complete installation).

. . . IN THE MINING INDUSTRY

Mines use National coils in the motors which power mine locomotives, shuttle cars, conveyors and other equipment. National "grew up" in the coal fields and really understands the electrical maintenance problems of the mining industry. The photo shows a typical armature coil for a mine locomotive motor.

. . . IN THE RAILROAD INDUSTRY



Some railroads send their traction motors to National shops for rewinding. Others perform the work in their own shops, using National replacement coils and winding supplies. The photo shows the variety of materials which go into a complete National rewinding kit for a traction motor armature.

. . . IN THE STEEL INDUSTRY

The steel industry depends on National for replacement coils because rugged, reliable National coils have proved their ability to meet the test of tough steel mill operating conditions. The photo shows armature coils for a DC mill motor being dipped in a silicone varnish to protect them against deterioration due to high temperatures.

When you need coils for any rotating electrical equipment, you can count on National for top quality, good service and a reasonable price. Ask your National field engineer for details on how National coils can help simplify your motor and generator maintenance problems. If you don't know him, just drop us a line and we'll arrange to have him get in touch with you.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

been a sales representative in the Philadelphia and Dallas districts prior to his appointment in 1951 as manager of the Indianapolis district. **John L. Wiedey** has been named manager of the Indianapolis district succeeding Mr. Metz. He joined the Allis-Chalmers St. Louis district office in 1946. Prior to his appointment as a representative in the Indianapolis district in 1952, he had been an application engineer in the company's switchgear section.

Lester M. Curtiss has been appointed executive assistant—operations to the administrative vice president at Lukens Steel Co. In addition, **Lloyd P. McAllister** was named general manager of production, and **Edward J. Charlton,** general manager of engineering and services.

Charles D. Preusch was appointed as chief metallurgist of Crucible Steel Co. of America's Spaulding Works in Harrison, N. J. He formerly was foundry metallurgist at Spaulding Works.

W. E. Korsan, formerly manager of Allis-Chalmers Manufacturing Co.'s St. Louis district, was appointed manager of sales of the company's electrical application department. **J. C. Lovelace** has been named manager of the St. Louis district succeeding Mr. Korsan.

LeRoy R. Brooks, president of Tool Steel Gear and Pinion Co., has been elected president of the American Gear Manufacturers Association for the period July 1, 1957 through June 30, 1958.

Dr. Albert Muller, until recently director of metallurgical research at the Air Reduction Central Research Laboratories, Murray Hill, N. J., has been appointed assistant to the president, Air Reduction Sales Co., a division of Air Reduction Co., Inc.

William F. Winemiller was named manager of the sales engineering department of Norton Co.'s Refractories Division. **George H. Powers,** refractories engineer in New York City since 1952, has been named assistant sales manager of the division.

Obituaries

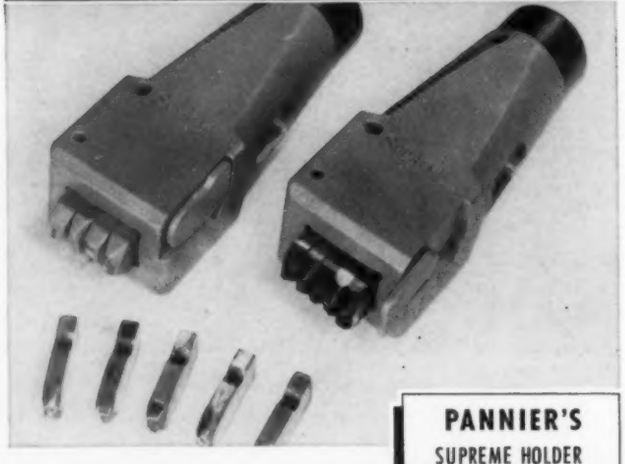
Frank R. Freyler, manager of the Mid-Atlantic Region of Allis-Chalmers Industries Group since 1950, died April 18 in Richmond, Va., at the age of 56. Mr. Freyler joined Allis-Chalmers in 1929 and was a sales engineer in the Philadelphia district until 1940 when he was named assistant manager of sales, electrical department, Norwood, Ohio, Works. In 1945 he was appointed Cincinnati district manager and in 1948 he became Philadelphia district manager.

Charles C. Cheyney, vice president in charge of sales for the Buffalo Forge Co., died April 25.

Leon A. Doughty, president of C & D Batteries, Inc. died May 18. He was 70.

George McKee, formerly superintendent mechanical department, Republic Steel Corp., died May 19.

ANOTHER *PANNIER* MASTER MARKER!



New Roto-Pin type lock is integral part of *all* Pannier Supreme Holders . . . eliminates loose, bent, dropped, or lost pins . . . flip it open to change type . . . flip it back to securely lock type in clear-marking position.

PANNIER'S SUPREME HOLDER WITH ROTO-PIN LOCK

Safe, fast type changing. Holder in variety of styles. Machined from High-Grade Bar Tool Steel. Hardened anvil maintains type alignment. Striking Head of Tool Steel . . . Replaceable to add long service life to Holder.

Write for complete data.

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MARKING DEVICES

THE PANNIER CORPORATION

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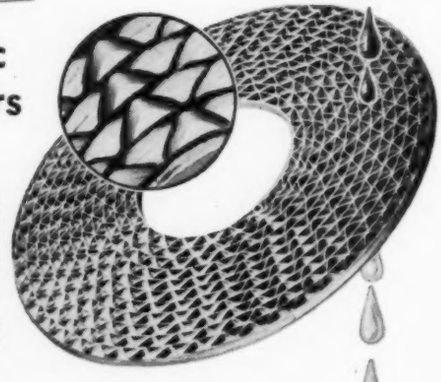
Offices: Los Angeles • Chicago • Cleveland • Philadelphia

FILTER FERROUS GRIT

out of Lubricating Oil . . . and Hydraulic Fluid . . . Minimize Cost of Maintenance and Delays

FERROFILTER®

Magnetic Separators



FERROFILTER GRID (right) . . . one of a strongly magnetized stack with 100's or 1000's of feet of grid edges which catch and hold finest iron particles. Magnified inset shows ferrous grit collected on grid edges.

Send for **BULLETIN PM-44**

Model PQ-6 for 3" pipe line available with screwed or flanged connections. Other sizes from 3/8" to 8".

S. G. FRANTZ CO., Inc.

Brunswick Pike and Kline Ave.

P.O. Box 1138, Trenton 6, N.J.

NOT ONE REJECT IN A HUNDRED!

Because all Industrial Cut Gears have Dimensional Tolerances Held Closer Than Heretofore Thought Practical!

When you specify "I.G." gears your Quality Control Department can relax. By actual customer checking it was found that Assembly Ready I.G. gears have reduced percentage of rejects to the vanishing point. This has been accomplished through a firm policy of keeping ahead in the use of latest gear cutting machinery. In keeping ahead, I.G. constantly keeps in mind the end result . . . the work to be performed by YOUR product. For precision cut gears—delivered promptly—let I.G. become your dependable Gear Department.

Steel mill roll table (covers removed to show I.G. gears). This is another instance where dependability is a MUST!

Write for complete, FREE "Gear Packet" showing Industrial Cut Gear products, applications, and services.

Herringbone Spur Helical Spiral Bevel Internal and other Gears

INDUSTRIAL GEAR MFG. CO.

4527 W. Van Buren St., Chicago 24, Ill.

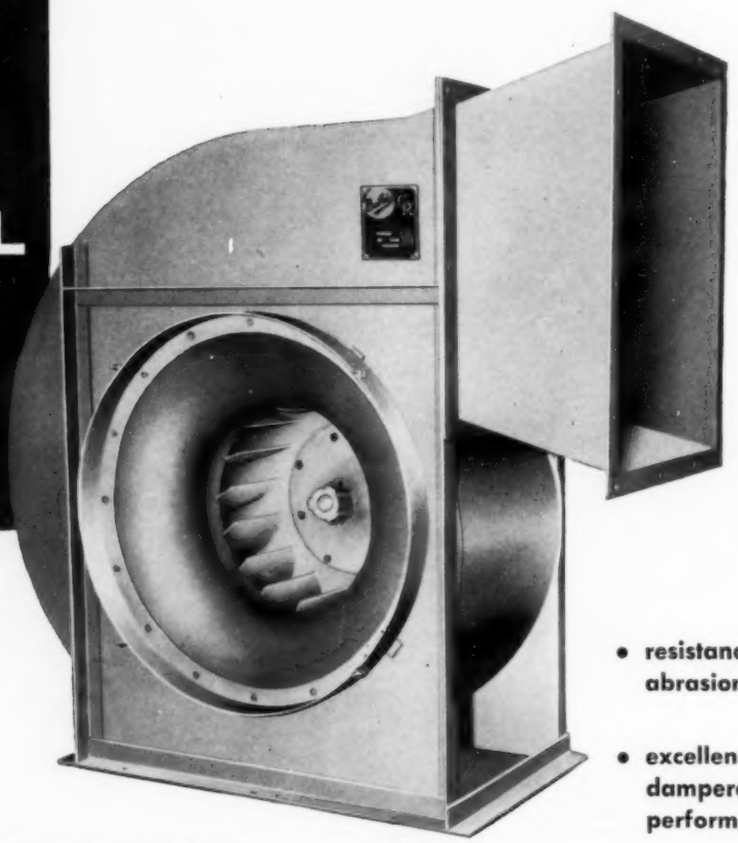
"Buffalo"

TYPE "CR" RADIAL WHEEL FAN FOR SEVERE INDUSTRIAL SERVICE

3 WHEELS TO MATCH YOUR PRESSURE VOLUME NEEDS

The Type "CR" Radial Wheel Fan is one of a series of "Buffalo" Fans to blanket ALL the varying requirements for mechanical draft and heavy industrial service in today's plants.

The "CR" has the high-pressure, wear-resistant characteristics so necessary for handling dust-laden air or draft service on stoker-fired boilers. It also makes possible selection of a smaller fan for many direct-connected applications — saving first cost. All this plus money saving mechanical efficiency.



- **resistance to abrasion**
- **excellent dampered performance**
- **rising pressure characteristic**
- **lower first cost**

In addition to the "CR", you may select a "BR" for higher capacity, lower pressure work — or a "DR" for higher pressure, lower capacity requirements — all in this long-lasting radial wheel series. And for inlet box volume control, these fans may be ordered with "Buffalo" Cantilevered Variable Inlet Vanes. These Vanes do not reduce open-position performance because there is no linkage or sources of turbulence on the inlet side. Write for Bulletin FD205 and see the "Q" Factor* that makes these fans a best buy for you!

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY
BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Three Rust-Oleum DIFFERENCES that save you time, money and metal!

GOES ON FASTER

No tedious surface preparations usually required — just scrape and wirebrush to remove rust scale and loose rust — then brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining rust.

STOPS RUST

Rust-Oleum's *specially-processed* fish oil vehicle works down through the rust into the tiny, microscopic pits in the bare metal where it drives out air and moisture to *stop rust.*

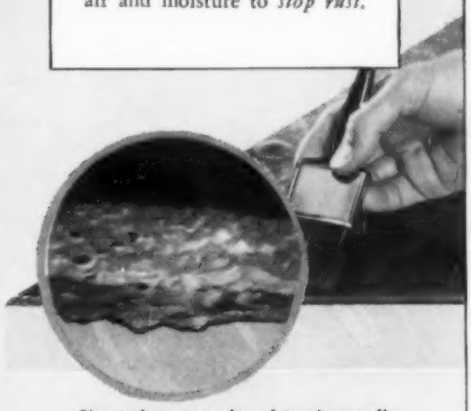
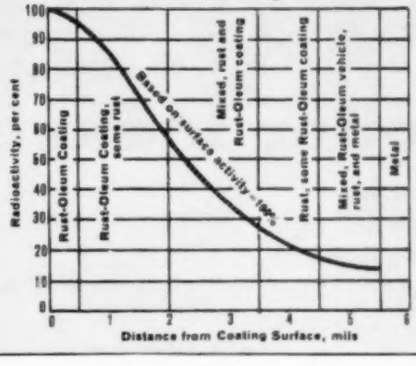
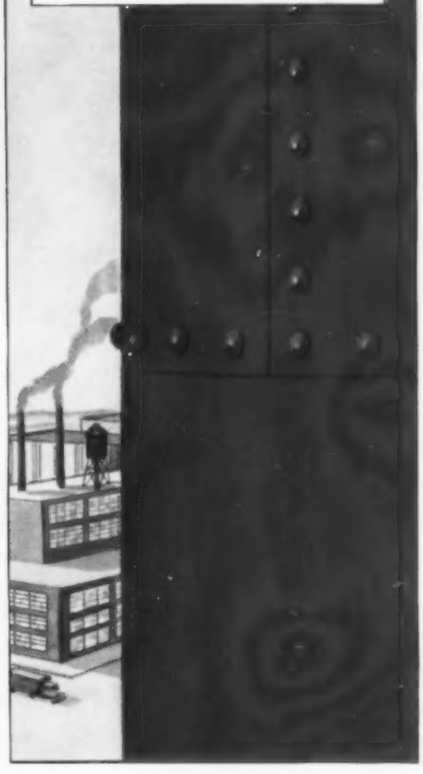


Chart shows results of tracing radio-activated Rust-Oleum through rust to bare metal by Geiger Counter.



LASTS LONGER

Applied over rust, Rust-Oleum lasts longer for the *over-the-years protection* you need. It resists sun, salt water, salt air, fumes, heat, humidity, moisture, weathering.



These are just a few of many important *differences* that separate Rust-Oleum from ordinary coatings. When you consider that Rust-Oleum covers approximately *30% more area,* depending upon surface condition and porosity . . . and the fact that Rust-Oleum finish coatings, with the same fish oil vehicle, are available in nearly every color for *double protection* . . . it's just good, common sense to use Rust-Oleum. Prompt delivery from Industrial Distributor stocks. Write for illustrated literature with color charts.

RUST-OLEUM®

STOPS RUST!®

Rust-Oleum is distinctive as your own fingerprint. Accept no substitute.

ATTACH TO YOUR LETTERHEAD — MAIL TODAY

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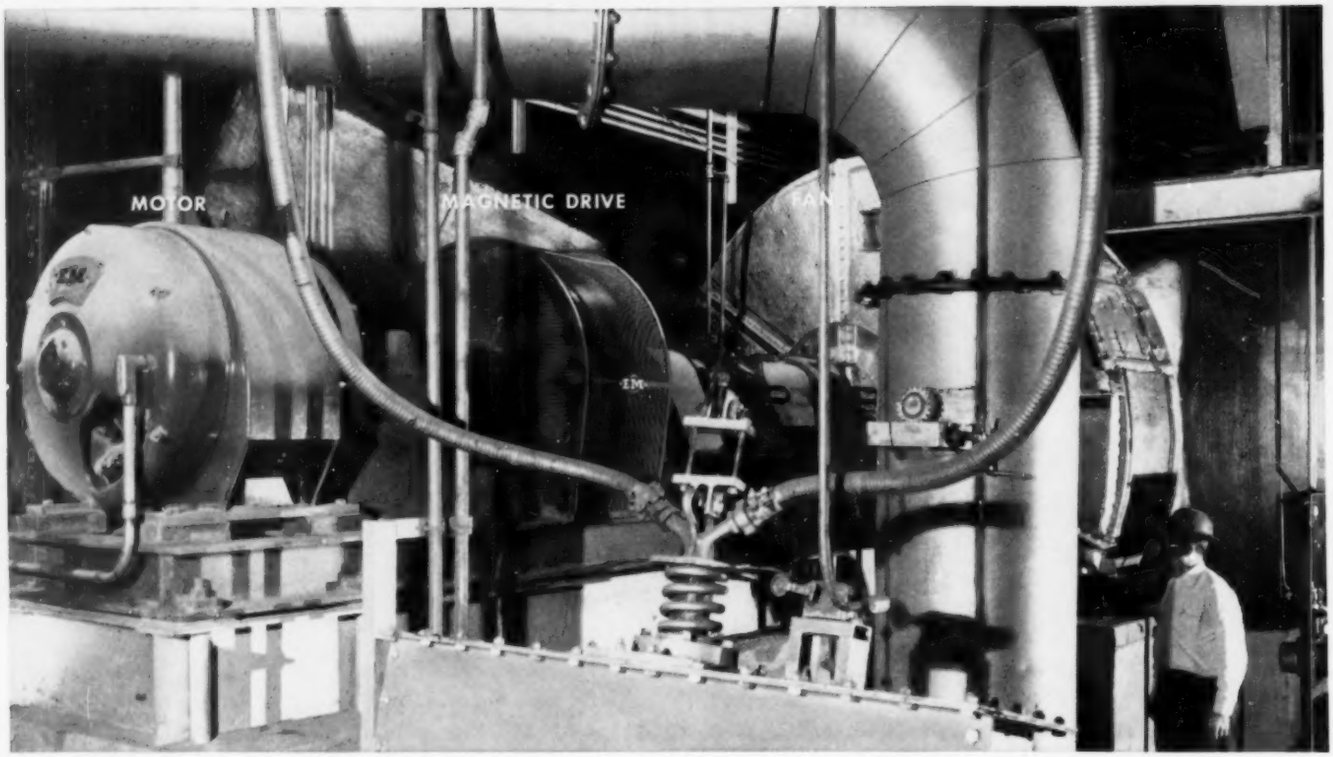
- ☐ Complete literature with color charts.
- ☐ 30-page report on Rust-Oleum penetration.
- ☐ Nearest source of supply.

Rust-Oleum and Stops Rust are brand names and registered trademarks of the Rust-Oleum Corporation.



A waste-heat boiler induced draft fan in a large steel mill receives driving power and precise speed control from a 200 hp, 720 rpm E-M Synchronous Motor and a 200 hp, 350/705 rpm EM Adjustable-Speed Magnetic Drive.

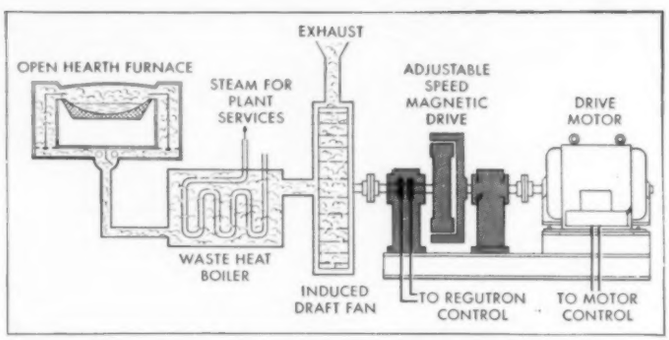
How to reduce erosion of waste-heat boiler induced draft fans

Many modern steel plants now use waste heat from banks of open hearth furnaces to produce steam for plant services. An induced draft fan draws waste gas through a waste-heat boiler to recover heat from open-hearth gases usually exhausted out a stack.

Speed control of this fan is essential for economical operation, and the E-M Adjustable-Speed Magnetic Drive is the best answer to this need. It transmits torque electromagnetically from the constant speed drive motor to the fan, responding automatically and precisely when speed changes are signalled. This Drive, with the sensitive E-M Regutron Control, provides *true* speed control regardless of variations in operating conditions.

Sizable reductions in fan blade erosion are achieved, as the fan is not required to run constantly at full speed against the highly abrasive gases when reduced output is wanted. The Magnetic Drive is equally effective and economical in drawing cool air through the boilers during shut-down for boiler maintenance or repair.

See how this Drive can save costs and increase over-all efficiency in your plant. Ask your nearest E-M sales engineer for details, and write for E-M Publication No. 1107 on Magnetic Drives.



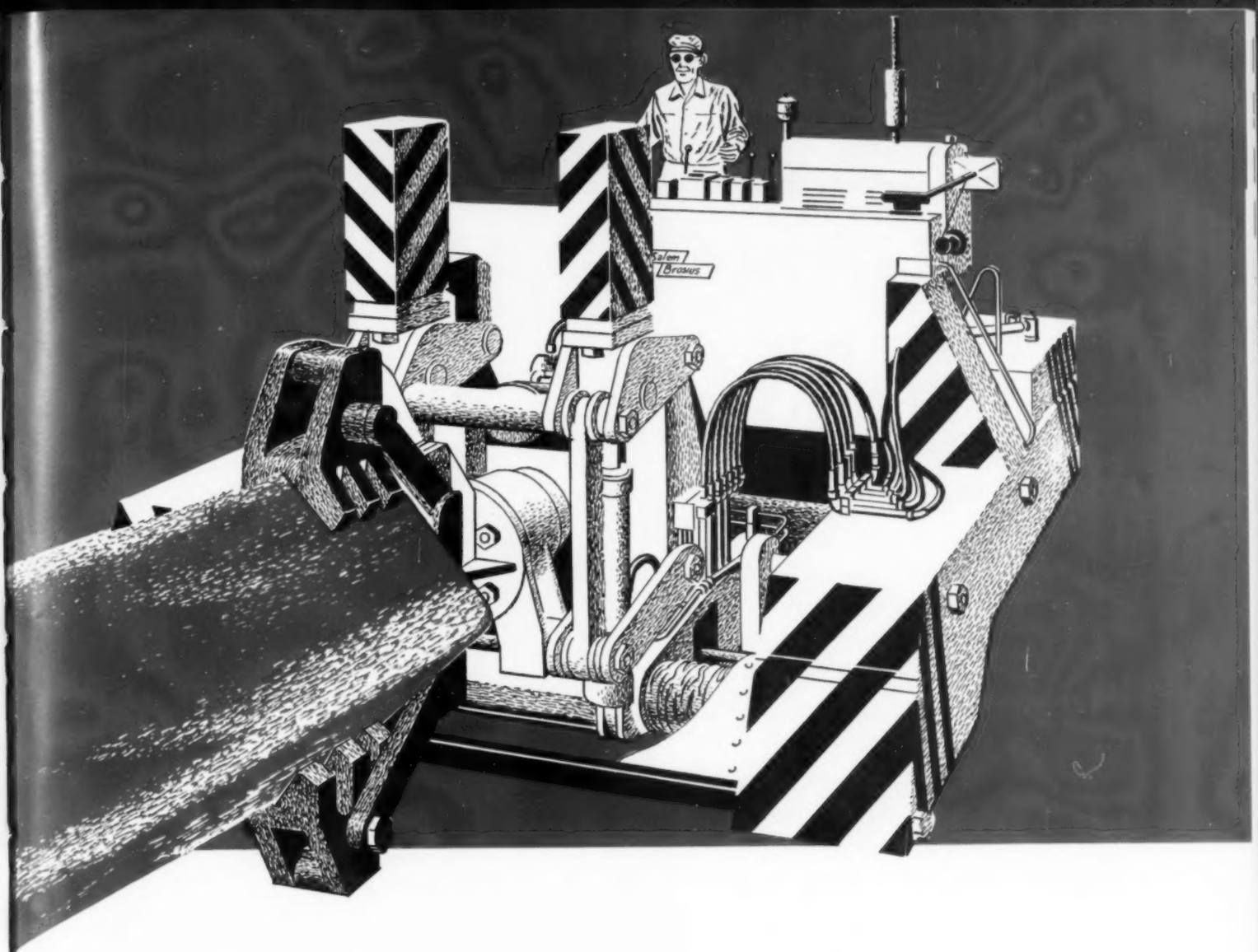
Here, in a simplified diagram, is how the E-M Adjustable-Speed Magnetic Drive fits into the Waste-Heat Boiler system, providing precise, automatic control of the induced draft fan.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

4400-TPA-2145

Magnetic Drives make draft fans do
EXACTLY WHAT YOU WANT THEM TO



New Salem-Brosius Manipulator

adds speed, safety and economy to heavy forging

This completely new Salem-Brosius all-hydraulic Auto-Floor Manipulator meets the trend of industry toward hammer and press forging of high alloy, stainless, and tool steels, and the many new extremely hard refractory-type alloys. The forging of these metals necessitates manipulating equipment of extreme ruggedness and durability.

This new machine, with its greater mass, new shock absorbing principles, heavier construction, and a new and superior hydraulic system, offers long, trouble-free service, low-cost maintenance, and increased finished forging production.

At hammer or press it raises, lowers, tilts, rotates or laterally moves the hot stock, satisfying handling requirements. Also, it can charge or draw forge shop furnaces, and operate with the facility of a fork-lift truck in billet handling. Call for a visit from a Salem-Brosius forging expert to show you how you can benefit from the use of this manipulator. There is no obligation.

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

In Canada: Salem Engineering Limited • 1525 Bloor Street West, Toronto 9, Ontario

SPECIAL MECHANICAL EQUIPMENT • INDUSTRIAL HEATING FURNACES • MATERIALS HANDLING EQUIPMENT

TRABON

CENTRALIZED LUBRICATION

Giant ore bridge buckets dig and load 17% more with Trabon lubrication

Now, lubricating this giant ore bridge bucket is simple and economical! All a man does is to connect a very inexpensive grease gun to a Trabon heavy duty feeder. All 40 bearings then receive the exact measured amount of grease they need in a matter of minutes. Downtime for lubrication is cut from 45 minutes to less than 5 minutes. Digging and blast furnace loading time is increased 17% each 8-hour day. Lubrication is now safe, dependable and positive since Trabon Centralized Lubrication Systems were installed at this Midwestern steel plant three years ago on three giant ore bridge buckets. Write today for further information.

Close up shows Trabon feeder system operating on one of three similarly equipped ore bridge buckets. All industry relies on Trabon for positive lubrication under rugged conditions.

Trabon

Trabon Engineering Corporation

28815 Aurora Road • Solon, Ohio

Centralized OIL AND GREASE SYSTEMS Matic-Jet CIRCULATING OIL SYSTEMS

Equipment News...

GAGE CONTROL

▲ An automatic gage-control system that incorporates "Magamp" regulators has been developed by the Westinghouse Electric Corp. for the adjustment of mill stands to obtain correct strip thickness. The system allows stands to get "on-gage" faster than do conventional manual methods and increases yields from the tandem mill process.

The new system utilizes a thickness gage between the first and second stands as a thickness-error indicating device. This error signal is fed to the first-stand screwdown control to reposition the screws and eliminate the error. This provides a coarse control of strip thickness. An additional thickness gage is located between the last stand and the reel, and provides an error signal for operating the vernier gage control regulator. This regulator controls gage by adjusting the tensions between the stands of the mill to assure that the exit thickness of the strip is on-gage.

Fast response is obtained by a combination of 400-cycle regulators designed to operate in conjunction with the main drive 400-cycle regulators of the cold reduction tandem mill.

THERMOCOUPLE

▲ The Bristol Co. has announced a new thermocouple for high temperature molten metal measurements up to 3100 F.

This thermocouple uses a metal-ceramic LT-1 secondary protecting tube, a vitrified alumina primary tube, and a platinum-platinum 10 per cent rhodium thermocouple. A curved stainless steel tube of any required length leads to a wooden grip and thermocouple assembly head. The standard model will have eight ft of armored connecting wire.

The protecting tube provides long life with fast response and resistance to thermal shock. Life tests indicate that the secondary tube will normally withstand about ten dips in molten steel between 2700 and 3100 F. Lower temperatures will give proportionally longer life.

The new unit is also available in a high speed model, with a single quartz protecting tube. The unit is equipped for fast interchange of tubes between measurements. Conversion between models is simple and fast.

HYDRAULIC SYSTEM

▲ A fully hydraulic system of control to operate valves in a new processing plant of the Texas Butadiene & Chemical Corp., has been developed. This hydraulic system was designed and built by Rivett, Inc., and opens the way to wide application of hydraulics to industries interested in automation.

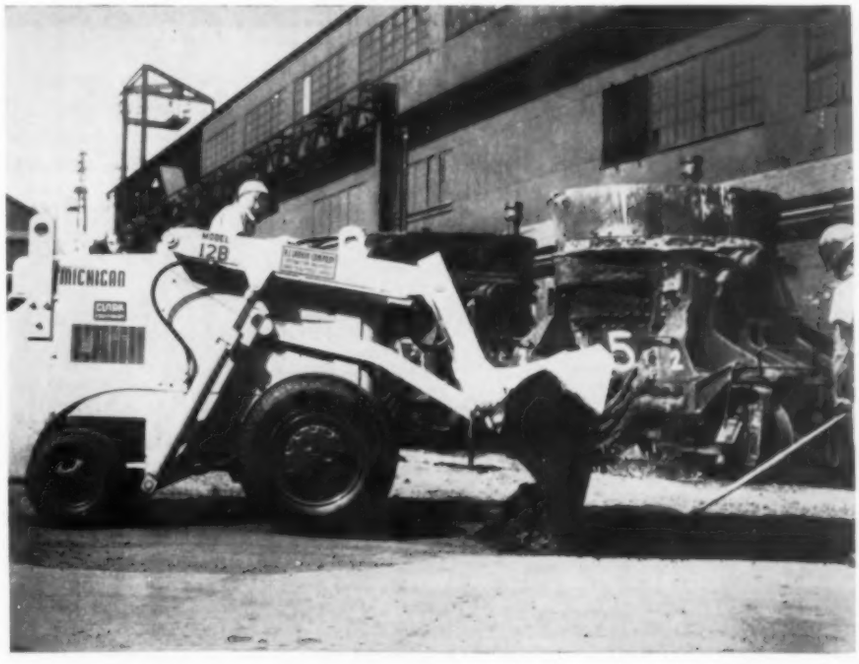
Hydraulics provided the plant with a precise and flexible control over product flow, plus simplified operation, a central power supply, lower initial cost and lower operating cost. Only one source of power was required—at the central power unit—reducing the actual connected horsepower from an estimated 400-500 hp that would have been needed for electrical control of the new plant to 30 hp required by the hydraulic system.

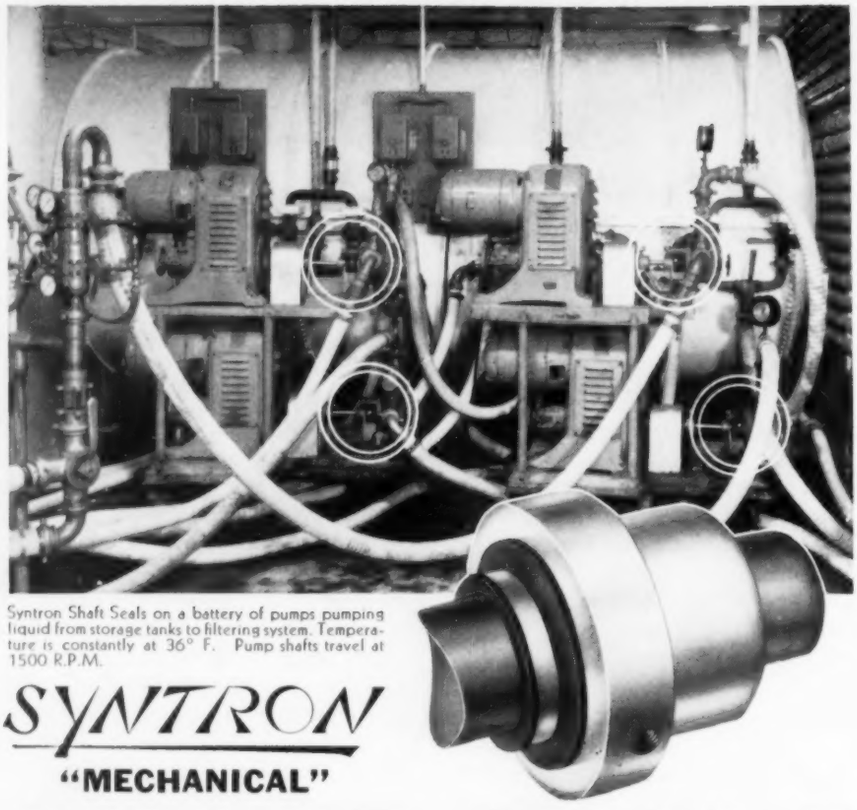
Product gate valves are operated by small, light hydraulic cylinders, which in turn are operated by solenoid valves located at the central control panels. Gate valve sizes handled by the new system range in size from 4 in. to 30 in. Operating times for the gate valves were cut to as low as one second for smaller valves to four seconds for those larger.

Independently operating control units were designed to control 98 gate valves involved. Each unit controls the necessary gate valves for seven reactor vessels, each of which has seven gate valves. To simplify operation and keep piping and electrical wiring to a minimum, common steel mounting panels, with drilled interconnections, for each gate valve circuit were designed. All valves and filters for operating each gate valve are mounted on

TRACTOR SHOVEL DISPLAYS VERSATILITY

This Michigan 12B tractor shovel, shown spreading asphalt during road work at U. S. Steel Corp.'s South Works, replaces trucks in this maintenance operation and also tows trailers after loading them with sand, gravel, dirt or trash. Good road speed (11.2 mphr) and big lifting capacity (3000 lb) provide the combination of power and maneuverability needed for multiple job assignments. Clark Equipment Co. is the manufacturer.





Syntron Shaft Seals on a battery of pumps pumping liquid from storage tanks to filtering system. Temperature is constantly at 36° F. Pump shafts travel at 1500 R.P.M.

SYNTRON

"MECHANICAL"

SHAFT SEALS

Provide a positive trouble-free seal around rotating shafts

Syntron Shaft Seals are successfully handling difficult liquids and gases. They provide a positive leak-proof seal around rotating shafts for long periods without maintenance or adjustment.

Syntron Shaft Seals are built as a single, easy-to-install unit. Seal faces are lapped to precision flatness. Inner sealing parts rotate with shaft—will not score or damage shaft. Self-lubricating, automatic pressure balance eliminates periodic adjustment and maintenance.

Stop leak waste, lower maintenance costs. Meet your sealing problems with Syntron Mechanical Shaft Seals . . . seals of proven dependability.

Syntron's years of experience are available to you—write to our application engineers for recommendations.

Builders of Quality Equipment for more than a Quarter-Century.

Other SYNTRON Equipment of proven Dependable Quality

AC TO DC POWER CONVERSION UNITS

LAPPING MACHINES

VIBRATING SCREENS

Write for complete catalog data — FREE

SYNTRON COMPANY

699 Lexington Avenue Homer City, Penna.

these panels. The panels for each reactor were then grouped and contained in a specially made, weather-resistant cabinet, with a separate door for each valve circuit. One of the cabinets in each unit contained an eighth panel with a circuit to operate an emergency reactor by-pass valve.

Power unit for the system includes two electric motor driven positive displacement pumps, with a third stand-by steam turbine driven pump. Gate valve cylinders are controlled by 4-way valves, operated by electric solenoid pilots.

To satisfy instantaneous horsepower demands during the system's approximately 20-minute cycle, and to reduce over-all horsepower requirements, the system includes a total of ten 10-gallon hydro-pneumatic accumulators. These discharge about 20 gallons of oil every three minutes, the peak demand times for the circuits.

High pressure oil from the power unit enters the panels and flows through full-flow, 40 micron, 2000 psi filters to the 4-way valves, which, in turn, control the flow of oil to the gate valve actuating cylinders.

As the cylinders move to open or close the gate valves, the exhaust oil flows out of the tank ports of the 4-way valves through pressure compensated flow control valves. By using these valves in the exhaust outlet, cylinder speeds are the same in both directions. Double end rod cylinders were used.

To assure trouble-free operation during the plant's continuous, 24-hr, 7-day schedule, it was most important that high filtration of hydraulic oil be incorporated. Rivett included, in addition to suction and return filters in the central power unit, a magnetic basket in the reservoir as an added precaution against passage of any ferrous particles in the oil. High pressure filters were also designed for each valve control panel.

Advantages of the change from electrical to hydraulic control were many. Control wiring and size of installation were reduced to approximately one-tenth of that required by a similar electrical control system. Rate of gate valve travel can easily be varied at any point in the stroke, and slow starts or stops can be gained by simple external valving. In addition, the actual operating forces required to open

can be prevented by USG® BRUSHES . . .

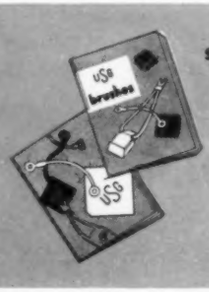
with STATITE® permanent shunt connections

When a motor is out . . . you're money out. If you want to eliminate downtime caused by shunts jarring loose or being pulled out, we suggest you try USG Brushes with Statite. Statite is a permanent shunt connection needing no hammerclips. It can't be jarred out even under severe operating conditions, and will assure your electric motors of steady, maintenance-free performance. In addition, Statite shunt connections, which eliminate troublesome rivets, retain their original low millivolt shunt drop, cannot oxidize, and are unaffected by temperature extremes. USG Brushes are manufactured in a variety of types and sizes for all applications from fractional horsepower to diesel generator. Grades available include carbon and carbon-graphite, electrographitic, graphite, metal graphite, and silver graphite.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 9, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



SEND THE ATTACHED COUPON . . .
for Engineering Handbook B-56 and Brush Grade Supplement.

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THE UNITED STATES GRAPHITE COMPANY
SAGINAW, MICHIGAN

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TITLE_____

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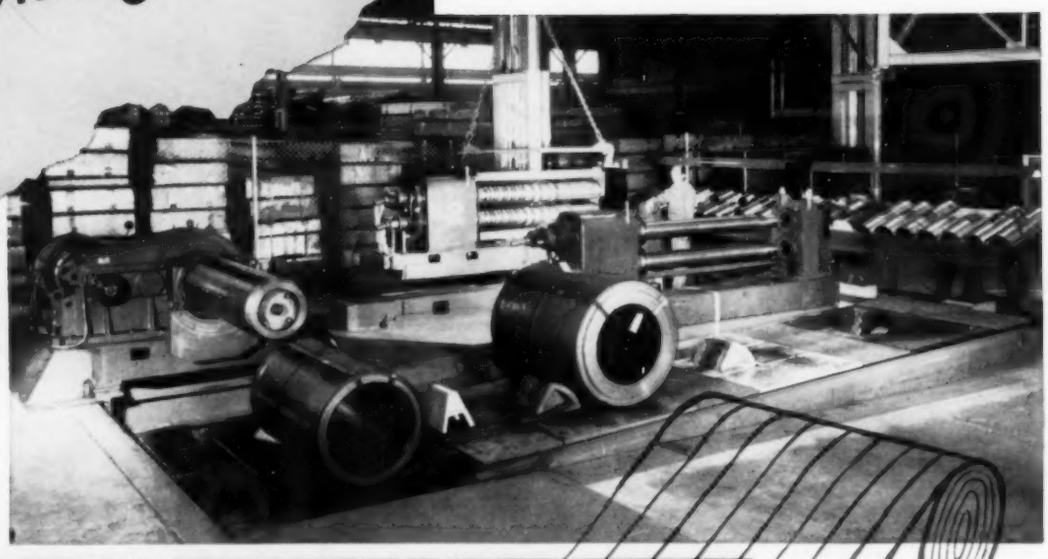
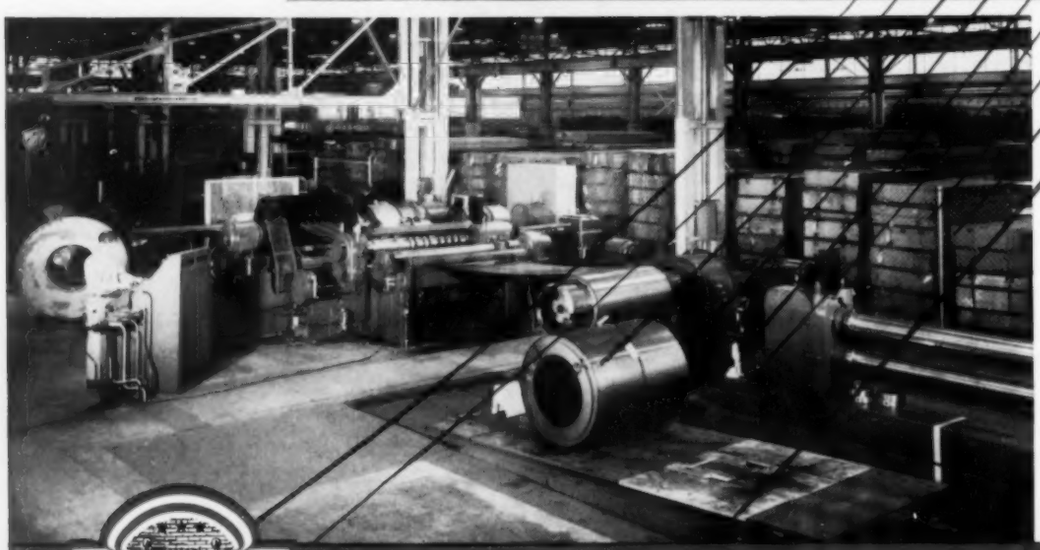
Step Up Production with Stamco Coiling Lines

Stamco Slitting and Coiling Lines will step up your production because they are designed to meet your particular specifications. Years of experience have led to the development of equipment that will meet every slitting and coiling requirement. Stamco slitting and coiling lines are now efficiently handling coils from 500 to 60,000 pounds and are designed to give dependable, maintenance-free service.

Write us, stating your requirements . . . we'll gladly give complete details—no obligation.



View shows coil and traverse, coil pay off reel, coil loading ramp and detachable slitter head.



Overall view of coiling line from entrance end.

LAY YOUR SHEARING PROBLEMS AT STAMCO'S DOOR

STAMCO, Inc., New Bremen, Ohio

or close the main gate valves can be varied by simply adjusting the relief valve.

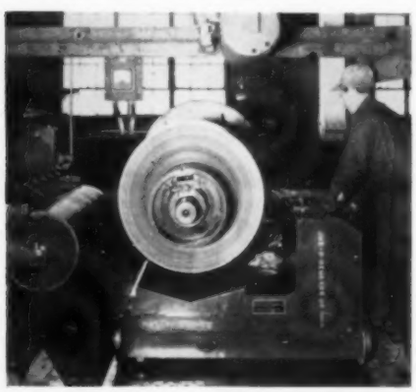
COIL LIFTERS

▲ Available from Lewis-Shepard Products, Inc., is a complete line of hydraulic and electro-hydraulic coil lifters in a wide range of capacities.

Of all steel construction, each has a V-type deck to facilitate the handling and lifting of coils of varying sizes. All have four flanged wheels for operating on tracks.

The 4000-lb capacity hydraulic coil lifter handles coils with as much as a 48-in. over-all diam and 30-in. width. Through the action of a double-acting hand pump, it will lift coils to heights of 18 in.

Coils weighing up to 5000 lb can be handled with a hydraulic footlift coil lifter. This unit handles coils of 36-in. widths and as much as 48-in.



diam. By use of the foot pedal, coils can be easily lifted as much as nine inches.

Also available is a hydraulic handlift coil lifter with an 8000-lb capacity. Actually a modification of a handlift truck, this model uses its pulling handle, when engaged, as the lifting device.

For coils weighing as much as 10,000 lb an electro-hydraulic coil lifter is offered. Designed to handle coils with diameters as much as 48-in. and 30-in. widths, lifting and driving the unit is accomplished through electro-hydraulic power. Coils can be lifted to 12-in. heights. Convenient throttle valve levers enable the operator to precisely spot loads.

Heavier coils are handled with the 20,000-lb capacity electro-hydraulic traction drive coil lifter. This unit will handle coils 50 in. wide of any diameter. Like the 10,000-lb model, it has a power lift (to 12 in.) and is

AT LARGE MIDWESTERN MANUFACTURING PLANT*

Diamond INDUSTRIAL TV

Fire-Watches 29 Acres of Roof

Saves $20,000 PER YEAR

Viewing Screens in basement guardroom enable guard to watch the roof easily and comfortably in addition to other duties.

Two tower-mounted Diamond ITV Cameras automatically sweep back and forth watching the 29 acres of roof. This installation has been in continuous operation since September, 1955.

Remotely controlled zoom lenses . . . remote control to stop, start or angle either camera, enables the guard to take a close look at anything suspicious. Remotely controlled windshield wipers on weatherproof camera housings keep viewing windows clear in bad weather. Fire hasn't a chance to get a serious start.

Savings in guard wages amount to $20,000 per year . . . will more than pay for the installation in a year. Lonely and sometimes unpleasant jobs are eliminated. Have *you* explored the money saving resources of Diamond ITV? Call your Graybar Distributor, or use the coupon below.

*Name on request. 7729

Distributed by Graybar Electric Company

DIAMOND POWER SPECIALTY CORP.
"FIRST IN INDUSTRIAL TELEVISION"
ELECTRONICS DEPT., P.O. BOX 57U
LANCASTER, OHIO

Please send me without obligation a copy of new bulletin showing how Diamond Industrial (Wired) Television will help me reduce costs, improve quality, increase sales and aid safety.

Name_____

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HERC-ALLOY

THE ORIGINAL ALLOY STEEL CHAIN

● Herc-Alloy is a special all-purpose chain with long-wearing properties and high resistance to impact loading.

● Herc-Alloy is sold in running lengths and in all types and sizes of sling chains assembled to customers' specifications.

● CM also produces a complete line of chain attachments and welded chain of all types including stainless steel and bronze.

● Write for literature covering Herc-Alloy Sling Chains, including helpful information on their assembly, care, use and inspection.

Hammerlok®

COUPLING LINKS

● Assemble or rebuild your own Herc-Alloy sling chains with all components furnished by your local distributor. Hammerlok is simple, safe, reusable. New Herc-Alloy assemblies can now be ordered with welded or Hammerlok Coupling Links as desired.

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Regional Offices: NEW YORK • CHICAGO • CLEVELAND
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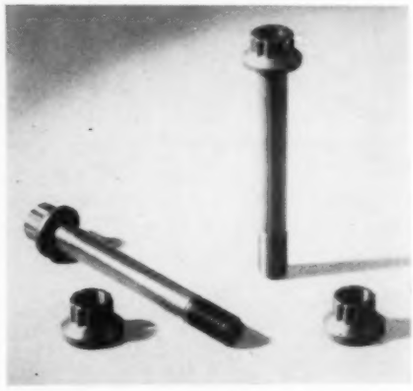
Herc-Alloy®

power propelled. The convenient throttle levers also allow "inching" the unit into position with a high degree of accuracy.

FASTENERS

▲ Steel superbolts have been announced by Standard Pressed Steel Co.

The new "Hi Tm 9" fasteners offer exceptional strength and temperature resistance. With minimum tensile strength at 170,000 psi at 900 deg F, the bolts are as much as 50 per cent stronger than stainless



and alloy steel fasteners currently used at this temperature. They are actually as strong at 900 deg as most present-day high-strength fasteners are at room temperature.

This could be duplicated in other structural parts, according to the company. Immediate applications for Hi Tm 9 include aircraft engines, power plant steam and gas turbines, high temperature nuclear and chemical process equipment.

LEAK DETECTOR

▲ A newly improved electronic leak detector—so sensitive it can detect one part of helium in two million parts of air—has been announced by General Electric Co.'s Instrument Department.

Based on an original development for the wartime Atomic Energy program, the re-designed mass spectrometer leak detector features extreme sensitivity, fast response and high resolution.

Ten times more sensitive than its predecessor, the new M-2 leak detector finds and locates leaks in vacuum or pressure systems. It is used by electronic industries, nuclear developments, military units, and research laboratories for quality control and production checks.

The leak detector readily detects

a leak rate of 1 x 10^{-10} standard cubic centimeters of air per sec, a leak rate so small that it would take more than 5000 years for one cubic centimeter of air at atmospheric pressure to leak into an evacuated vessel.

The device has a response as low as two seconds and a high resolution which helps eliminate the possibility of response to elements other than the tracer gas (hydrogen or helium) introduced into a system for leak detection.

Electronic circuitry of the M-2 detector and the use of plug-in components has simplified maintenance and operation. The mass spectrometer tube, for example, can be removed and replaced without shutting down the vacuum system.

No special training is needed to operate this leak detector. The operator simply opens and closes one valve. The device to be leak-tested is evacuated and connected to the leak detector. A small jet of tracer gas (usually helium) is then sprayed over the surfaces of the equipment under test. If a leak is present, the sensitive instrument locates the leak which is indicated on the operator's control panel. An audible alarm is also available for indicating a detected leak.

FLEXIBLE COUPLING

▲ A flexible coupling known as Para-flex has been added to the Dodge Manufacturing Corp.'s line of power transmission machinery.

The ability to handle angular mis-alinement, parallel mis-alinement and end-float, and in any combination, is only one of many advantages claimed for the coupling. The flexible member also cushions shock loads and diminishes torsional vibration, thus protecting both the driver and the driven machine.

Heart of the Para-flex coupling is a tire with synthetic tension members bonded together in rubber. In fact, this new coupling has been made possible by the technological advance in the manufacture of modern automobile and truck tires, engineered to carry tremendous loads at high speeds and stand terrific shocks. The four-way flexing body of Para-flex outperforms the most complex coupling mechanisms, yet operates with the simplicity and dependability of a modern tire.

Protects Metals at Red Hot Temperatures!

UP TO 2200°F

Heatproof Coating Stops Corrosion, Scaling and Oxidation

MARKAL "S-R" Coatings were developed to protect metals, graphite or carbon parts against scaling, corrosion, oxidation, or carbon and hydrogen penetration at temperatures up to 2200°F. MARKAL "S-R" Coatings are excellent for the protection of stacks, radiant tubes, retorts, carburizing grids, mufflers, manifolds, etc.

MARKAL "S-R" Coatings will not peel or crack at high temperatures and are not affected by rapid heating and cooling cycles.

MARKAL Coatings are manufactured in a complete range of types for specific applications. Write for a free copy of Catalog MPC. The **MARKAL COMPANY,** 3087 W. Carroll Ave., Chicago 12, Illinois.

COWLES
TRIMMING KNIVES

Assure more continuous production and more tonnage from each grind

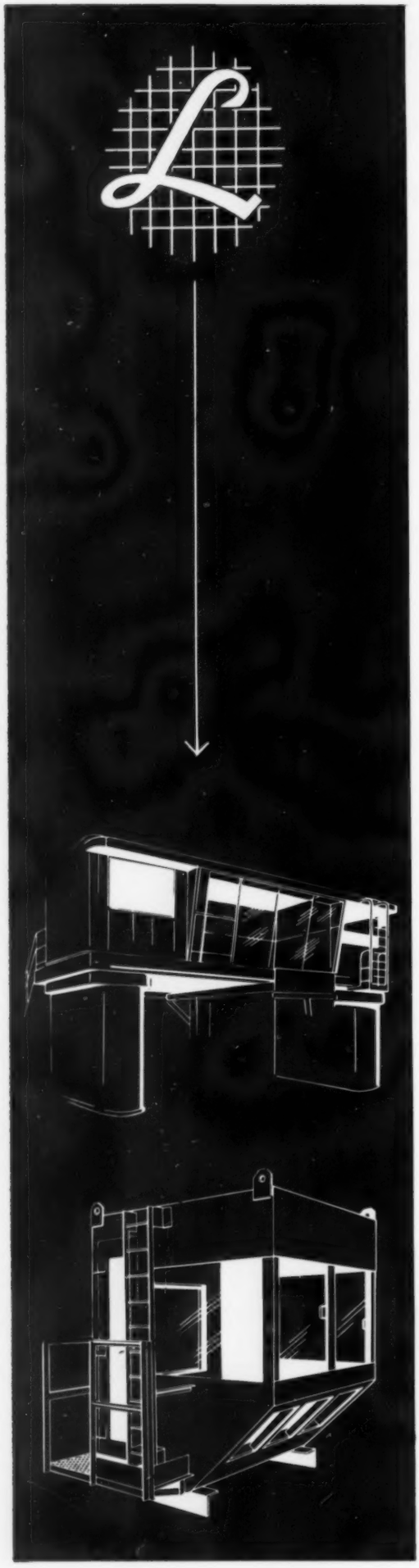
Cowles knives stay on the job longer. They keep mills in continuous production with minimum downtime for knife changes. Manufactured from individually hammered forgings, and heat treated to assure maximum durability, they meet industry's most exacting requirements. Any diameter, face or bore. Widely used by all principal producers and processors. *Let us quote on your requirements!*

COWLES TOOL COMPANY

2070 WEST 110th STREET • CLEVELAND 2, OHIO

Specializing in the Manufacture of

ROTARY SLITTING KNIVES • SPACING COLLARS • ROTARY TRIMMING KNIVES • ROLL TURNING TOOLS • EDGING ROLLS • CUT-OFF KNIVES STANDARD AND SPECIALLY ENGINEERED TOOLS FOR ALL FERROUS AND NON-FERROUS PROCESSING, TRIMMING AND FORMING REQUIREMENTS.



The overwhelming majority of cranes and pulpits being equipped with air conditioning are equipped with

Lintern

Aire-Rectifiers

The reasons why are contained in Bulletin AC-573, just off the press. May we send you a copy?

Larco, inc.

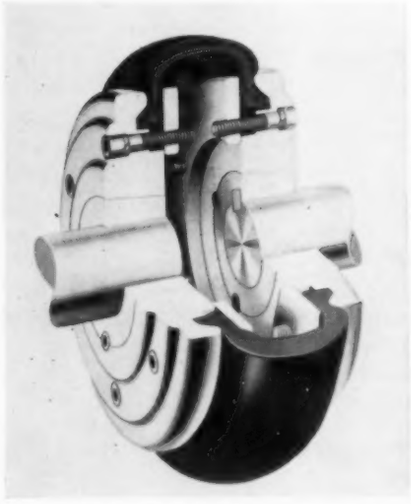
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS

ROUTE 20 EAST,
PAINESVILLE, OHIO

The coupling consists of the flexible tire clamped between two hubs which are mounted on the shafts to be coupled. The flexible member is held between the flanges and clamp rings of the hubs.

Both hubs of the coupling are machined to take taper-lock bushings. These give the equivalent of a shrunk-on fit on the shaft and permit quick and easy application to shafts of different diameters without costly reboring.

The tire has a transverse split molded into it, which permits easy installation and makes replacement possible without moving driver or driven machine. To make a change it is only necessary to loosen the cap screws enough to allow removal of the tire and to fit a new one in



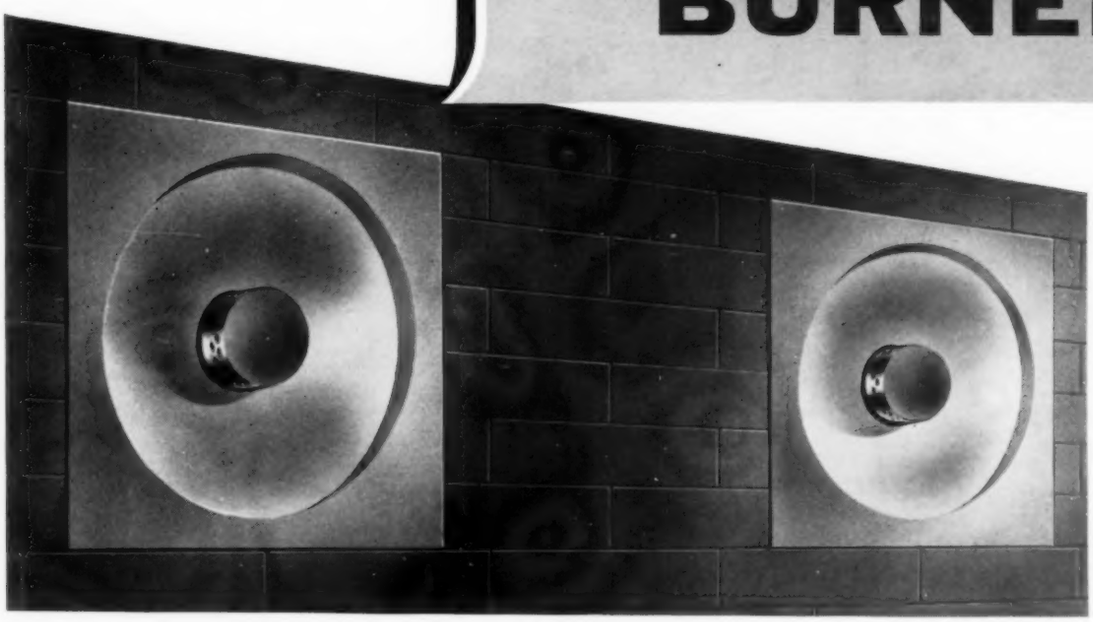
place. Even in very confined spaces this simple operation can be accomplished in a few minutes.

The coupling will take angular mis-alinement up to four degrees, parallel mis-alinement up to $\frac{1}{8}$ in., and end-float up to $\frac{5}{16}$ in.—contingent upon the size of the coupling and the duration of the conditions—or it will take all of these simultaneously. The resilience of the flexible member cushions shocks to a remarkable degree, smoothing out the load for both driver and driven machine. Torsional vibration developed by internal combustion engines, the amplitude of which increases greatly at critical points in the speed range, is absorbed to a great degree.

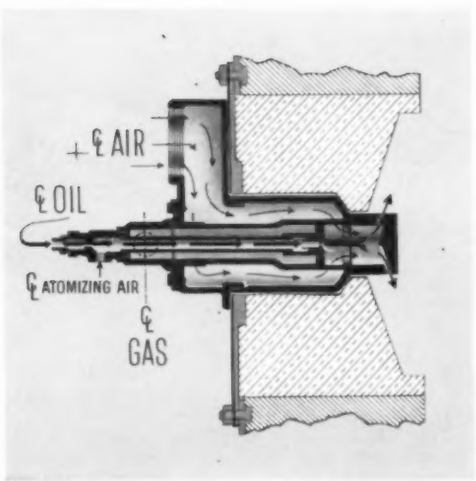
Because there is no metal-to-metal contact in the P coupling, it requires no lubrication. No maintenance or regular inspection for lubrication is needed. Safety is promoted by flush design—all cap

for intense concentration of heat . . .

The BLOOM HTR BURNER



The Bloom HTR Burner provides identical operation on either gas or oil.

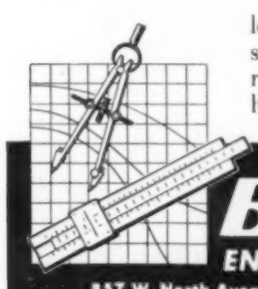


PATENT PENDING

This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

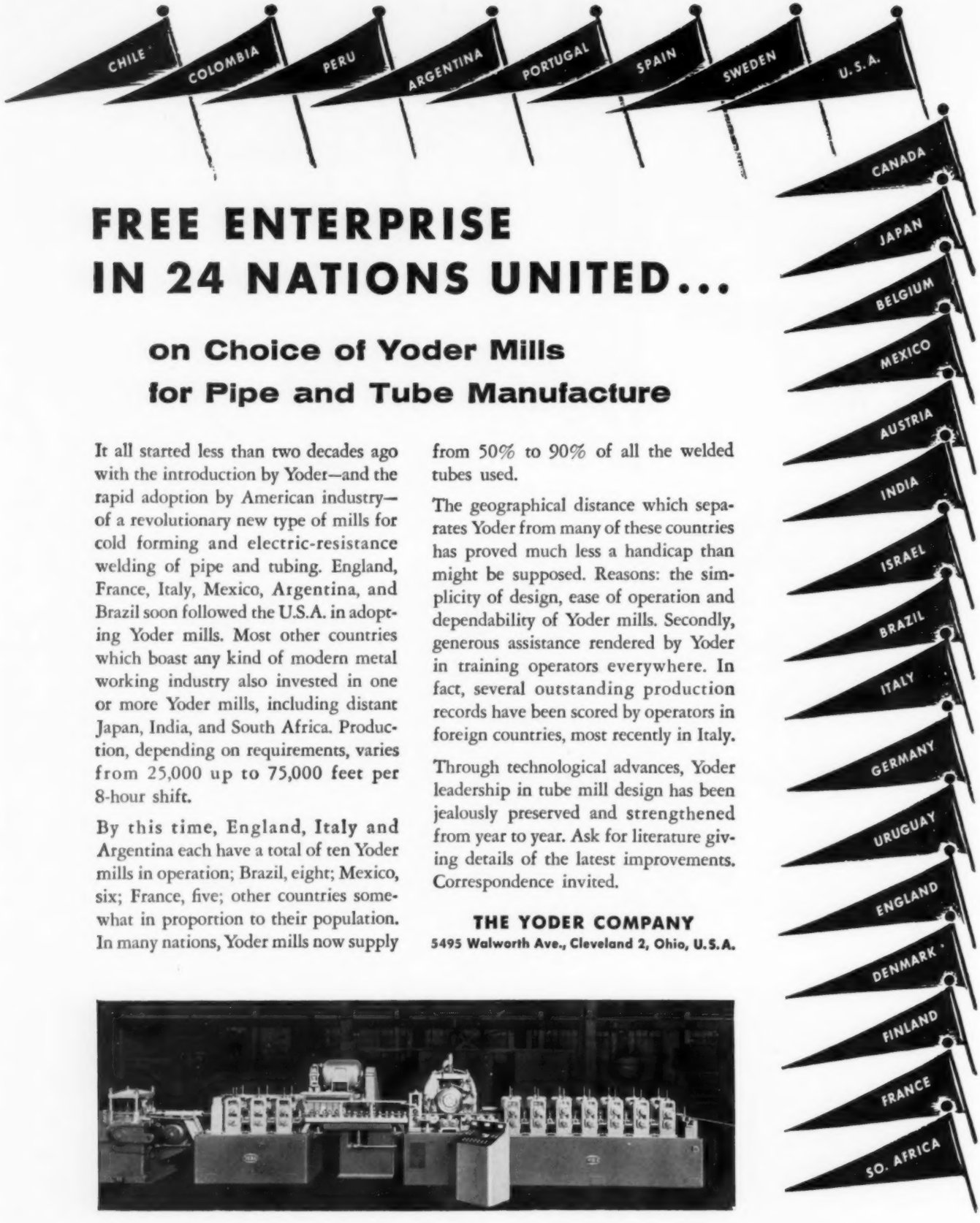
This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.



BLOOM ENGINEERING CO., INC.

857 W. North Avenue Pittsburgh 33, Pa.



FREE ENTERPRISE IN 24 NATIONS UNITED...

on Choice of Yoder Mills for Pipe and Tube Manufacture

It all started less than two decades ago with the introduction by Yoder—and the rapid adoption by American industry—of a revolutionary new type of mills for cold forming and electric-resistance welding of pipe and tubing. England, France, Italy, Mexico, Argentina, and Brazil soon followed the U.S.A. in adopting Yoder mills. Most other countries which boast any kind of modern metal working industry also invested in one or more Yoder mills, including distant Japan, India, and South Africa. Production, depending on requirements, varies from 25,000 up to 75,000 feet per 8-hour shift.

By this time, England, Italy and Argentina each have a total of ten Yoder mills in operation; Brazil, eight; Mexico, six; France, five; other countries somewhat in proportion to their population. In many nations, Yoder mills now supply from 50% to 90% of all the welded tubes used.

The geographical distance which separates Yoder from many of these countries has proved much less a handicap than might be supposed. Reasons: the simplicity of design, ease of operation and dependability of Yoder mills. Secondly, generous assistance rendered by Yoder in training operators everywhere. In fact, several outstanding production records have been scored by operators in foreign countries, most recently in Italy.

Through technological advances, Yoder leadership in tube mill design has been jealously preserved and strengthened from year to year. Ask for literature giving details of the latest improvements. Correspondence invited.

THE YODER COMPANY
5495 Walworth Ave., Cleveland 2, Ohio, U.S.A.

ENGINEERING **YODER** MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES

screws are countersunk, metal surfaces are finished all over, there are no protruding parts. The coupling is designed to occupy a minimum of space on the shaft.

FANS

▲ Offered by Aerovent Fan Co., Inc., is a new line of all-purpose fans, comprising five heavy-duty units for spot cooling, drying or processing, in all types of portable or stationary applications.

The line includes lightweight Model "39" with cast-iron or rubber-tired wheels, portable Model "56" with column and large pedestal, stationary heavy-duty Model "S," and the "Steeler," an exceptionally rugged portable unit designed expressly for the steel industry. These are available in sizes 24 in. to 48 in. The portable utility fan is offered in sizes 16 to 36 in.

All of the above fans may be ordered with 2, 4 or 6-blade "Macheta" airfoil propellers, to fit their particular application. Directional air discharge of each is adjustable to 180 F. All are of heavy-gage steel construction, with steel safety guards at front and rear.

SELF-CLEANING FILTER

▲ A new dual purpose, fully automatic filter with interchangeable filter elements is now available from Bowser, Inc.

The new filter can be equipped with filter elements designed for lubricating oils and similar liquids, or equipped with filter elements suited to coolants.

✻ from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Both types of elements are interchangeable within the filter case providing maximum versatility for today's varied filtering requirements.

The filter media for lubricating oils is constructed of wire-wound stainless steel or bronze, wrapped around a cast iron core, with a port opening range of 0.002 to 0.015.

The filter media for coolants offers a porosity range of 0.020 to 0.045, utilizing a brass perforated sheet as filter media.

An interval repeat timer provides completely automatic self-cleaning and permits adjusting the length of the cleaning cycle from a minimum 20 sec to a maximum 30-min period.

Long filtration cycles are possible with an extra large sump located below the filtering units. The new design incorporates a large inspection port which also serves as a cleanout door.

A wide range of sizes are available with flow rates ranging from 120 gpm to 1200 gpm.

RADIANT HEATING TUBES

▲ A more economical radiant heating tube for use under severe operating conditions has been announced by the National Alloy Div., Blaw-Knox Co.

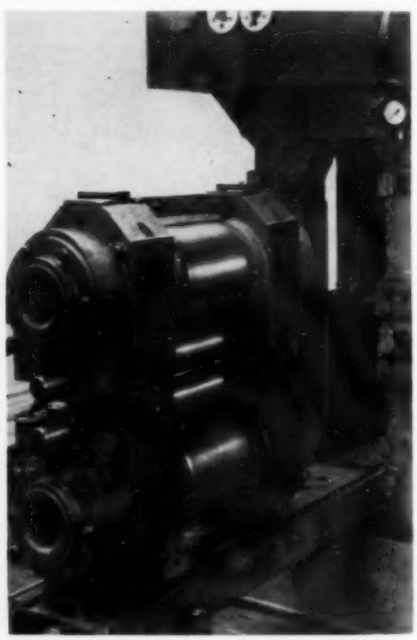
Special construction of this composite tube increases its service life because critical sections of the assembly are cast from alloys with greater strength and heat resisting properties.

By using NA22H alloy, for the critical segments of the assembly and lower grade alloys such as 35-15 and/or 25-12 for the balance of the unit, it is more nearly possible to achieve optimum operating conditions resulting in uniform performance of the entire assembly.

At the same time, while the overall service which can be expected from the composite tube is doubled or tripled, resulting in less furnace downtime costs, initial investment in the assembly is considerably less than that for a radiant tube assembly completely fabricated from NA22H.

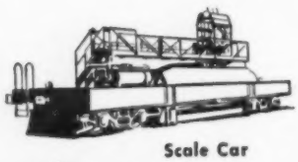
ROLLING MILLS

▲ Development of a range of heavy duty, high precision 2-high/4-high combination rolling mills for use in both ferrous and non-ferrous metals laboratories and pilot plants has been announced by Loma Machine Manufacturing Co., Inc.

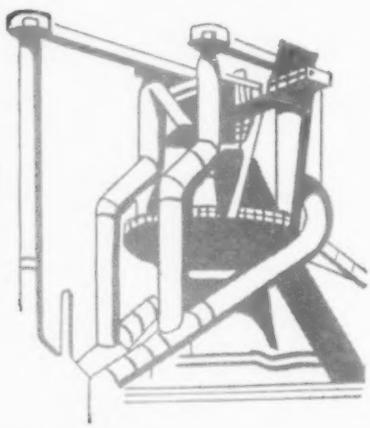


Designed to take the heavy pass reductions and to maintain the close thickness tolerances required in the processing of such materials as high

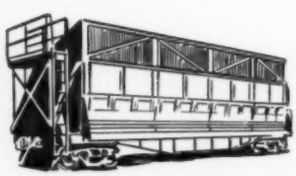
WHEREVER *performance* **COUNTS**



Scale Car



100-ton Ore Transfer Double Compartment, Bottom Dump



Coke Quenching Car

Atlas Cars are built to resist the high wear factors of continuous service handling abrasive materials. Extra factors of safety in brakes, controls, visibility, and signal devices are incorporated for foolproof service.

Each car is engineered to meet the operating needs of the plant where it will be used.

ATLAS
CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

Consult Atlas for your Steel Plant Cars

ENGINEERS AND MANUFACTURERS SINCE 1896

T. S. PETERSEN

"Investing in America has made our country great"

"The American competitive enterprise system was founded on the work and savings of the people and has produced the highest standard of living in history.

"Our people of their own free will have made all forms of investment from Government Savings Bonds to venture capital for new enterprise. Competitive enterprise is dependent on the continued supply of these funds, which benefit consumers, workers, and the national interest.

"Investing in America through Savings Bonds and venture capital has helped make our country great and this idea needs to be brought home to all the people."

T. S. PETERSEN, *President,*
Standard Oil Company of California.

If your employees do not enjoy the advantages of the Payroll Savings Plan—or if participation is less than 50%—act right now. A letter to Savings Bonds Division, U.S. Treasury Department, will bring prompt assistance from your State Director. He will help you put an application blank into the hands of every employee. It requires a minimum of effort—and it is a gesture that will win the approval of the people in your company.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

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PREVENTIVE MAINTENANCE

FOR PIPE, PIPE JOINTS, FITTINGS, COUPLINGS, TANKS, TIE RODS and CONDUIT... ABOVE and BELOW GROUND

STEEL MILLS DEPEND ON

TAPECOAT®

...The Quality Coal Tar Coating in Handy Tape Form

For your preventive maintenance program on mill lines, you need the best possible protection at lowest possible cost. Since 1941, TAPECOAT has proved its superiority in combating corrosion in this type of service. This quality coal tar coating in handy tape form resists moisture, acids, alkalis, chemical fumes, and other severe corrosive and abrasive conditions. Here's low-cost protection for pipe around quenching stations, pickling vats, and wherever any combination of elements create corrosive hazards.

TAPECOAT is self-bonding, easy to apply with the use of a torch. No skilled help is required. It is low in cost considering its high quality and continuing protection which cuts maintenance and replacement expense.

TAPECOAT comes in rolls of 2", 3", 4", 6", 18" and 24" widths. Also available in asphalt.

Write for brochure and prices

The TAPECOAT Company
Originators of Coal Tar Coating in Tape Form
1529 Lyons Street
Evanston, Illinois

temperature super-alloys, nuclear fuels, stainless steels and refractory metals, the mills have exceptionally high separating force and torque transmission capacities. They are currently available in backup roll diameters from 6 in. to 15 in., in work roll diameters from ¾ in. to 5 in., and in face widths up to 24 in. The machines offer the greatest possible versatility and can readily be converted from one to another setup with the aid of a special roll changing rig.

A representative 5 in. & 15 in. x 10 in. reversing mill is used in a 15 in. x 10 in. 2-high setup for either hot or cold breakdown rolling of slabs; in a 5 in. & 15 in. x 10 in. 4-high setup for either hot or cold intermediate rolling of strip; and in a 2½ in. & 15 in. x 10 in. 4-high setup for the cold finish rolling of strip to very thin gauges and close tolerances. Furthermore, the outboard housing of the mill is readily moved to increase the face width from 10 in. to 20 in., so that 15 in. x 20 in. grooved rolls can be used in a 2-high setup for the hot or cold rolling of rounds, squares and other shapes.

Depending upon size and application, the mills are furnished with needle roller or oil film sleeve bearings on the journals, with manual or twin-motor screwdown and with either constant-speed a-c or variable-speed d-c drives.

Book Reviews

"A Handbook of Hard Metals," by W. Dawihl has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 162 pages, 9½ x 6 in., is cloth bound and sells for $10.00. This book is a condensed translation of the original work which appeared in German under the title "Handbuch der Hartmetalle." The first part of the book deals with the scientific principles of sintering and the second part describes the technical production of hard metals. It is divided into 14 chapters which present an introduction, the metallography of hard metal, the preparation of the powder mixtures for pressing, the process of sintering hard metal alloys, the properties of sintered

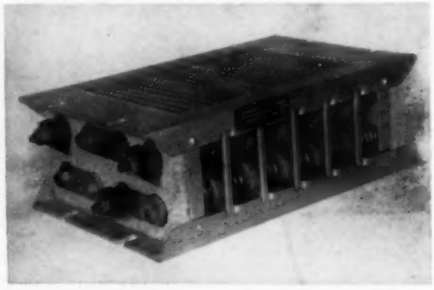
GUYAN RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co., 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

GUYAN MACHINERY COMPANY
LOGAN, W. VA.

hard metals, the processes taking place during the wear of hard metal alloys, cast tungsten carbide alloys, hard-facing alloys, diamond hard metal, tungsten-free hard metals, the production of the initial and accessory materials, the production of the powder mixtures for pressing, shaping, final sintering. References are made in detail to the experimental methods and results of investigators in order to assist further development. Also included are many tables, charts and diagrams.

"Control of Steel Construction to Avoid Brittle Failure," prepared by the Plasticity Committee of the Welding Research Council and edited by M. E. Shank, has recently been published by the Welding Research Council, 29 West 39th Street, New York, N. Y. The book contains 184 pages, 6 x 9½ in., is cloth bound, and sells for $4.50. The volume is divided into three parts: Part I, "Materials" discusses notch toughness, behavior, size effect, metallurgical factors affecting brittleness, specifications; Part II, "Fabrication" considers effect of cold work and strain aging, effect of fabrication notches, welding procedures; Part III, "Design" contains general considerations, design, welding, fatigue. In addition to these points there is also included a summary, suggested further reading section, glossary of terms and test specimens. Wherever possible an attempt has been made to indicate the economic advantages and penalties associated with various possible procedures and courses of action connected with avoidance of brittle failure in steel structures. Numerous illustrations have been included to supplement and explain the text.

"The Design and Construction of Engineering Foundations," by F. D. C. Henry, has recently been published by the McGraw-Hill Book Co., Inc., New York, N. Y. The book contains 549 pages, 6 x 9 in., is cloth bound, and sells for $9.00. This book contains 11 chapters covering geological and allied aspects of foundation construction, principles of soil mechanics, structural and soil mechanics aspects of foundation design, individual footings, continuous footings and rafts, retaining

(Continued on page 264)

Outlasts All Other Refractory Bonding Mortars

IMPORTANT FACTS

- ***In Blast Furnaces***

Because it contains but a small percentage of iron found in other bonding mortars, Super #3000 is more resistant to failure of linings due to carbon deposition and alkali attack. Its dried density and abrasion resistance are highest of all. It's stronger than the brick it bonds.

- ***In Open Hearths***

Used for laying or patching refractory brick in ladles, spouts and kindred places, Super #3000 greatly increases its life.

- ***In Electric Furnaces***

Troweling a ¼" thick layer of Super #3000 against the steel shell, then pushing the brick and bonding them in place against the wet mortar, provides exceptional protection for the shell when molten metal cuts through the brickwork.

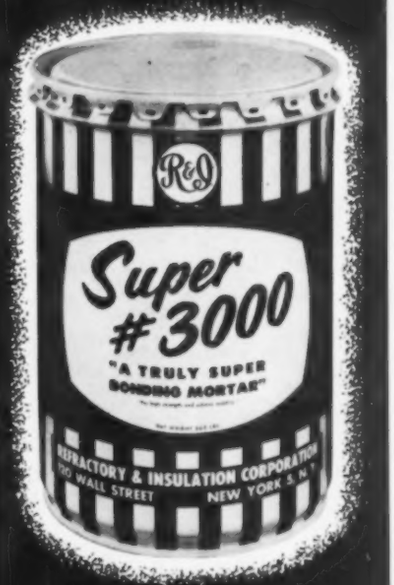
- ***In Soaking Pits***

Fire brick and tile in soaking pit covers, set up with Super #3000, increase service life of the covers as much as 50%. Recuperator tubes laid up and wash coated with Super #3000 are sealed air-tight.

- ***In Coke Ovens***

Pouring new floors or repairing old floors with Super #3000, without cooling down the oven or need for expensive labor, is a short cut that saves thousands of dollars in but a few months.

Ready Mixed
Ready-to-use
Trowels perfectly
to smooth finish



Air sets weld-tight, to highest dried density. It does not spall, shrink or crack at low, medium or high temperatures to 3000° F. Has unsurpassed strength—high heat resistance to flame erosion and mechanical abrasion.

✓*Make Your Own Test*

Write for generous free sample of Super #3000

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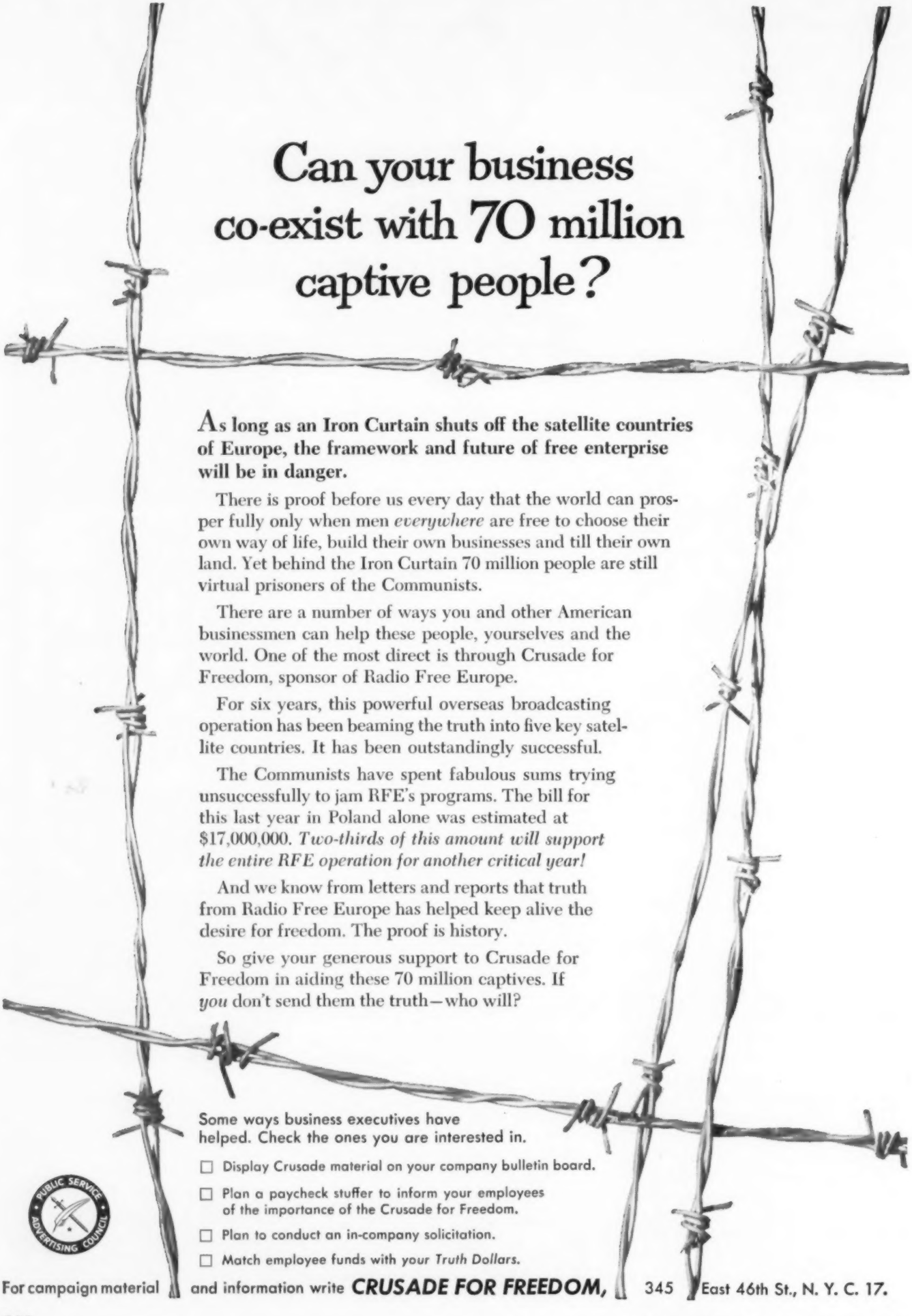

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BOOK REVIEWS

(*Continued from page 261*)

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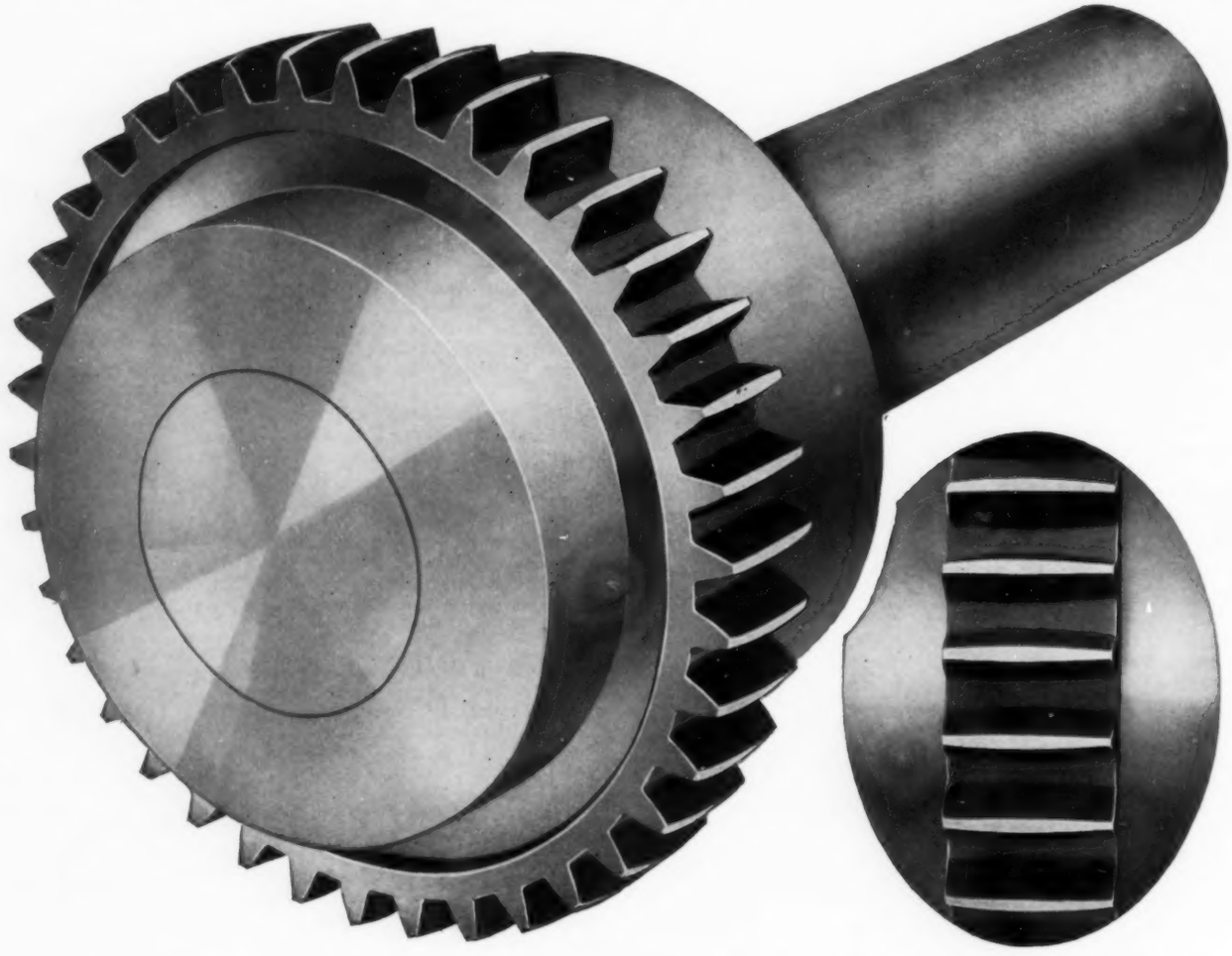

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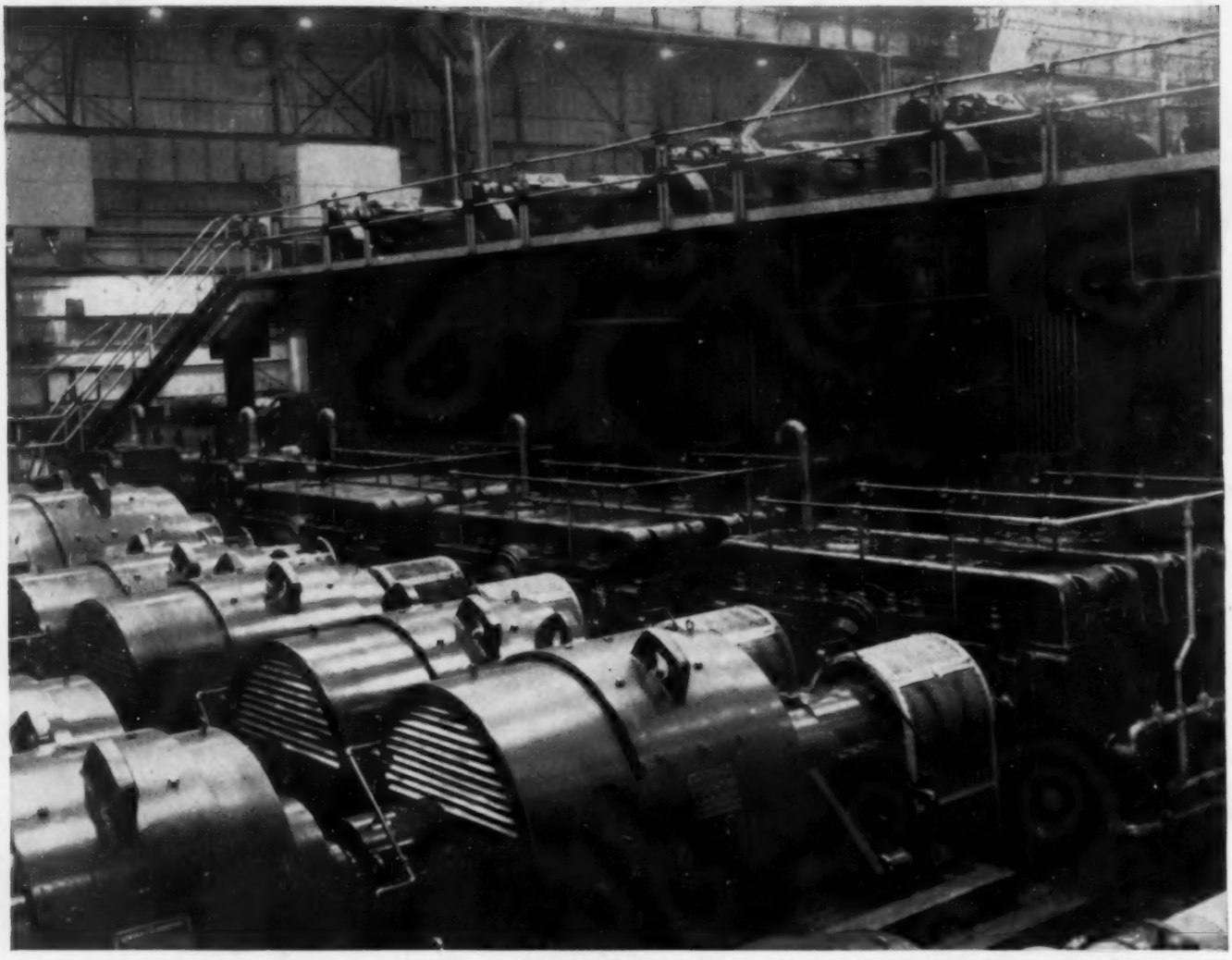

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